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THE ECONOMIC DISTURBANCES SINCE 1873.

By Hon. DAVID A. WELLS, LL. D.

II.

WHEN the historian of the future writes the history of the nineteenth century he will doubtless assign to the period embraced by the life of the generation terminating in 1885, a place of importance, considered in its relations to the interests of humanity, second to but very few, and perhaps to none, of the many similar epochs of time in any of the centuries that have preceded it; inasmuch as all economists who have specially studied this matter are substantially agreed that, within the period named, man in general has attained to such a greater control over the forces of Nature, and has so compassed their use, that he has been able to do far more work in a given time, obtain a much larger product, "measured by quantity in ratio to a given amount of labor," and reduce the effort necessary to insure a comfortable subsistence in a far greater measure, than it was possible for him to accomplish twenty or thirty years anterior to the time of the present writing. In the absence of sufficiently complete data, it is not easy, and perhaps not possible, to estimate accurately, and specifically state the average saving in time and labor in the world's work of production and distribution that has been thus achieved. In a few departments of industrial effort the saving in both of these factors has certainly amounted to seventy or eighty per cent; in not a few to more than fifty per cent.* Mr. Edward Atkinson, who has

* According to the United States Bureau of Labor (report for 1886), the gain in the power of production in some of the leading industries of the United States "during the past fifteen or twenty years," as measured by the "displacement of the muscular labor" formerly employed to effect a given result (i. e., amount of product), has been as follows: In the manufacture of agricultural implements, from 50 to 70 per cent; in the manufacture of shoes, 80 per cent; in the manufacture of carriages, 65 per cent; in the

made this matter a special study, considers one third as the minimum average that can be accepted for the period above specified.* Other authorities are inclined to assign a considerably higher average. The deductions of Mr. William Fowler, Fellow of University College, London, are to the effect that the saving of labor since 1850 in the production of any given article amounts to forty per cent;† and the British Royal Commission (minority report, 1886) characterizes the amount of labor required to accomplish a given amount of production and transport at the present time as "*incomparably* less" than was requisite forty years ago, and as "being constantly reduced."

But be this as it may, out of such results as are definitely known and accepted have come tremendous industrial and social disturbances, the extent and effect of which—and more especially of the disturbances which have culminated, as it were, in later years—it is not easy to appreciate without the presentation and consideration of certain typical and specific examples. To a selection of such examples, out of a large number that are available, attention is accordingly next invited.

Let us go back, in the first instance, to the year 1869, when an event occurred which was probably productive of more *immediate* and serious economic—industrial, commercial, and financial—changes than any other event of this century, a period of extensive war excepted. That was the opening of the Suez Canal. Before that time, and since the discovery by Vasco da Gama, in 1498, of the route to India by the Cape of Good Hope, all the trade of the Western hemisphere with the Indies and the East toiled slowly and uncertainly around the Cape, at an expenditure in time of from six to eight months for the

manufacture of machines and machinery, 40 per cent; in the silk-manufacture, 50 per cent, and so on.

* In a print-cloth factory in New England, in which the conditions of production were analyzed by Mr. Atkinson, the product per hand was found by him to have advanced from 26,531 yards, representing 3,382 hours' work in 1871, to 32,391 yards, representing 2,695 hours' work in 1884—an increase of 22 per cent in product, and a decrease of 20 per cent in hours of labor. Converted into cloth of their own product, the wages of the operatives in this same mill would have yielded them 6,205 yards in 1871, as compared with 9,737 yards in 1884—an increase of $56\frac{32}{100}$ per cent. During the same period of years the prices of beef, pork, flour, oats, butter, lard, cheese, and wool in the United States declined more than 25 per cent.

A like investigation by the same authority of an iron-furnace in Pennsylvania showed that, comparing the results of the five years from 1860 to 1864 with the five years from 1875 to 1879, the product per hand advanced from 776 tons to 1,219 tons; that the gross value of the product remained about the same; that the number of hands was reduced from 76 to 71; and that consumers gained a benefit of reduction in price from $27.95 per ton to $19.08.

† "Wages have greatly increased, but the cost of doing a given amount of work has greatly decreased, so that five men can now do the work which would have demanded the labor of eight men in 1850. If this be correct, the saving of labor is 40 per cent in producing any given article."—*Appreciation of Gold*, WILLIAM FOWLER, *Fellow of University College, London, 1886.*

round voyage. The contingencies attendant upon such lengthened voyages and service, as the possible interruption of commerce by war, or failure of crops in remote countries, which could not easily be anticipated, required that vast stores of Indian and Chinese products should be always kept on hand at the one spot in Europe where the consumers of such commodities could speedily supply themselves with any article they required; and that spot, by reason of geographical position and commercial advantage, was England. Out of this condition of affairs came naturally a vast system of warehousing *in* and distribution *from* England, and of British banking and exchange. Then came the opening of the canal. What were the results? The old transportation had been performed by ships, mainly sailing-vessels, fitted to go round the Cape, and, as such ships were not adapted to the Suez Canal, an amount of tonnage, estimated by some authorities as high as two million tons, and representing an immense amount of wealth, was virtually destroyed.* The voyage, in place of occupying from six to eight months, has been so greatly reduced that steamers adapted to the canal now make the voyage from London to Calcutta, or *vice versa*, in less than thirty days. The notable destruction or great impairment in the value of ships consequent upon the construction of the canal did not, furthermore, terminate with its immediate opening and use; for improvements in marine engines, diminishing the consumption of coal, and so enabling vessels not only to be sailed at less cost, but also to carry more cargo, were, in consequence of demand for quick and cheap service so rapidly effected, that the numerous and expensive steamer constructions of 1870–'73, being unable to compete with the constructions of the next two years, were nearly all displaced in 1875–'76, and sold for half, or less than half, of their original cost. And within another decade these same improved steamers of 1875–'76 have, in turn, been discarded and sold at small prices as unfit for the service of lines having an established trade, and replaced with vessels fitted with the triple-expansion engines, and saving from eighteen to twenty-five per cent in the consumption of fuel. To which may be added that an iron cargo-steamer of 2,000 tons, which even as late as 1883 cost £24,000 ($120,000) in Great Britain to build, can now (1887) be built with all the modern improvements for about £14,000 ($70,000). In all commercial history, probably no more striking illustration can be found of the economic principle that nothing more clearly marks the rate of material progress than the rapidity with which what is old and has been considered wealth is destroyed by the results of new inventions and discoveries.

Again, with telegraphic communication between India and China

* "The canal may therefore be said to have given a death-blow to sailing-vessels, except for a few special purposes."—From a paper by Charles Magniac, indorsed by the "London Economist" as a merchant of eminence and experience, entitled to speak with authority, read before the Indian Section of the London Society of Arts, February, 1876.

and the markets of the Western world, permitting the dealers and consumers of the latter to adjust to a nicety their supplies of commodities to varying demands, and with the reduction of the time of the voyage to thirty days or less, there was no longer any necessity of laying up great stores of Eastern commodities in Europe; and with the termination of this necessity, the India warehouse and distribution system of England, with all the labor and all the capital and banking incident to it, substantially passed away. Europe, and to some extent the United States, ceased to go to England for such supplies. If Austria wanted anything of Indian product, it stopped *en route*, by the Suez Canal, at Trieste; if Italy, at Venice or Genoa; if France, at Marseilles; if Spain, at Cadiz. As a rule, also, stocks of Indian produce are now kept, not only in the countries, but at the very localities of their production, and are there drawn upon as they are wanted for immediate consumption, with a greatly reduced employment of the former numerous and expensive intermediate agencies.* Thus, a Calcutta merchant or commission agent at any of the world's great centers of commerce contracts through a clerk and the telegraph with a manufacturer in any country—it may be half round the globe removed—to sell him jute, cotton, hides, spices, cutch, linseed, or other like India produce.† An inevitable steamer is sure to be in an Eastern port, ready to sail upon short notice; the merchandise wanted is bought by tele-

* In illustration of this curious point, attention is asked to the following extract from a review of the trade of British India, for the year 1886, from the "Times," of India, published at Bombay: "What the mercantile community"—i. e., of Bombay—"has suffered and is suffering from, is the very narrow margin which now exists between the producer and consumer. Twenty years ago the large importing houses held stocks, but nowadays nearly everything is sold to arrive, or bought in execution of native orders, and the bazaar dealers, instead of European importers, have become the holders of stocks. The cable and canal have to answer for the transformation; while the ease with which funds can be secured at home by individuals absolutely destitute of all knowledge of the trade, and minus the capital to work it, has resulted in the diminution of profits both to importers and to bazaar dealers."

† Familiar as are the public generally with the operations of the telegraph and the changes in trade and commerce consequent upon its submarine extension, the following incident of personal experience may present certain features with which they are not acquainted: In the winter of 1884 the writer journeyed from New York to Washington with an eminent Boston merchant engaged in the Calcutta trade. Calling upon the merchant the same evening, after arrival in Washington, he said: "Here is something, Mr. ——, that may interest you. Just before leaving State Street, in Boston, yesterday forenoon, I telegraphed to my agent in Calcutta, 'If you can buy hides and gunny-bags at — price, and find a vessel ready to charter, buy and ship.' When I arrived here (Washington), this afternoon (4 P. M.), I found awaiting me this telegram from my partner in Boston, covering another from Calcutta, received in answer to my dispatch of the previous day, which read as follows: '*Hides and gunny-bags purchased, vessel chartered, and loading begun.*'"

Here, then, as an every-day occurrence, was the record of a transaction on the other side of the globe, the correspondence in relation to which traveled a distance equivalent to the entire circumference of the globe, all completed in a space of little more than twenty-four hours!

graph, hurried on board the ship, and the agent draws for the price agreed upon, through some bank, with the shipping documents. In four weeks, in the case of England, and a lesser time for countries intermediate, the shipment arrives; the manufacturer pays the bill, either with his own money or his banker's; and, before another week is out, the cotton and the jute are going through the factory; the linseed has been converted into oil, and the hides are in the tannery being transformed into leather. What has happened in the case of East India produce seems also likely to happen in the case of the great product of Australia—namely, wool—which for many years has been shipped mainly to London for sale and distribution. For with the increased facilities and reduction in the cost of travel and transportation by the Suez Canal route, the tendency in recent years has been to transfer the market for this wool to the country of its growth; as European Continental, and to some extent American, manufacturers are finding out that by this new arrangement they can have their raw material delivered to them within two or three months of the time of purchase, instead of three or four from the date of shipment to London, and at the same time avoid, to a considerable extent, the "profits" and the "corners" of middle-men and speculators. Under these circumstances the day is probably not far distant when the whole wool-crop of Australia, like the cotton-crop of the United States, will be sold before shipment; and another long-established "course" of trade, which has brought buyers from all the world to London will be broken up, to the temporary injury and loss of some, but to the greater advantage of the many. And in anticipation of this change, the largest warehouses in the world, some covering an area of five acres, have recently been erected in Melbourne, Sydney, and other Australian cities.

Importations of East Indian produce are also no longer confined in England and other countries to a special class of merchants; and so generally has this former large and special department of trade been broken up and dispersed, that extensive retail grocers in the larger cities of Europe and the United States are now reported as drawing their supplies direct from native dealers in both China and India.

Another curious and recent result of the Suez Canal construction, operating in a quarter and upon an industry that could not well have been anticipated, has been its effect on an important department of Italian agriculture—namely, the culture of rice. This cereal has for many years been a staple crop of Italy, and a leading article of Italian export—the total export for the year 1881 having amounted to 83,598 tons, or 167,196,000 pounds. Since the year 1878, however, rice grown in Burmah and other parts of the far East has been imported into Italy and other countries of Southern Europe in such enormous and continually increasing quantities, and at such rates, as to excite great apprehensions among the growers of Italian rice, and largely diminish

its exportation—the imports of Eastern rice into Italy alone having increased from 11,957 tons in 1878 to nearly 70,000 tons in 1883.

That the same causes are also exerting a like influence upon the marketing of the cereal crops of the United States is shown by the circumstance that the freight rates on the transport of grain from Bombay to England, by way of the Suez Canal, have declined from 32·5 cents per bushel in 1880, to 16·2 cents in 1885; and to the extent of this decline has the ability of the Indian ryot to compete with the American grain-grower, in the markets of Europe, been increased.

How great was the disturbance occasioned in the general prices of the commodities that enter into Eastern commerce by the opening of the Suez Canal, and how quickly prices respond to the introduction of improvements in distribution, is illustrated by the following experience: The value of the total trade of India with foreign countries, exclusive of its coasting-trade, was estimated at the time of the opening of the canal in 1869, at £105,500,000 ($527,500,000). In 1874, however, the value was estimated at only £95,500,000, or at a reduction of ten per cent; and the inference might naturally have been that such a large reduction as ten millions sterling ($50,000,000) in five years, with a concurrent increase in the world's population, could only indicate a reduction of quantities. But that such was not the case was shown by the fact that 250,000 tons more shipping was employed in transporting commodities between India and foreign countries in 1874 than in 1869; or, that while the value of the trade, through a reduction of prices had notably declined during this period, the quantities entering into trade had so greatly increased during the same time, that 250,000 tons more shipping (mainly steam, and therefore equivalent to at least 500,000 more tons of sail) were required to convey it.

In short, the construction of the Suez Canal completely revolutionized one of the greatest departments of the world's commerce and business; absolutely destroying an immense amount of what had previously been wealth, and displacing or changing the employment of millions of capital and thousands of men; or, as the London "Economist" has expressed it, "so altered and so twisted many of the existing modes and channels of business as to create mischief and confusion" to an extent sufficient to constitute one great general cause for a universal commercial and industrial depression and disturbance.

The deductions from the most recent tonnage statistics of Great Britain come properly next in order for consideration. During the ten years from 1870 to 1880, inclusive, the British mercantile marine increased its movement, in the matter of foreign entries and clearances alone, to the extent of twenty-two million tons; or, to put it more simply, the British mercantile marine exclusively engaged in foreign trade did so much more work within the period named; and yet the number of men who were employed in effecting this great movement had decreased in 1880, as compared with 1870, to the extent of about

three thousand (2,990 exactly). What caused this? The introduction of steam hoisting-machines and grain-elevators upon the wharves and docks, and the employment of hydraulic appliances and steam-power upon the vessels for steering, raising the sails and anchors, pumping, and discharging the cargo; or, in other words, the ability, through the increased use of steam and improved machinery, to carry larger cargoes in a shorter time, with no increase—or, rather, an actual decrease—of the number of men employed in sailing or managing the vessels.

Statistical investigations of a later date furnish even more striking illustrations to the same effect from this industrial specialty. Thus, for 1870, the number of hands actually employed for every 1,000 tons capacity, entered or cleared, of the British steam mercantile marine, is reported to have been 47, but in 1884 it was only 28; or seventy per cent more manual labor was required in 1870 than in 1884 to do the same work. In sailing-vessels the change, owing to a lesser degree of improvement in the details of navigation, has been naturally smaller, but nevertheless considerable; 28 hands being required in 1884 as against 33 in 1870 for the same tonnage entered or cleared; to which it may be added that if in these comparisons the tonnage of freight actually transported had been taken, in place of tonnage entered and cleared, whether light, partially, or fully loaded, the difference in the labor required for maritime transportation in favor of 1884 would undoubtedly have been even greater. Another fact of interest is, that the recent increase in the proportion of large vessels constructed has so greatly increased the efficiency of shipping, and so cheapened the cost of sea-carriage, to the advantage of both producers and consumers, that much business that was before impossible has become quite possible. Of the total British tonnage constructed in 1870, only six per cent was of vessels in excess of 2,000 tons burden; but in 1884 fully seventeen per cent was of vessels of that size, or larger. Meanwhile, the cost of new iron ships has been reduced, in Great Britain, from $90 per ton in 1872–'74, to $65 in 1877, $60 in 1880, and less than $40 in 1885–'86. Prior to about the year 1875, ocean-steamships had not been formidable as freight-carriers. The marine engine was too heavy, occupied too much space, consumed too much coal. For transportation of passengers, and of freight having large value in small space, they were satisfactory; but for performing a general carrying trade of the heavy and bulky articles of commerce, they were not satisfactory. A steamer of the old kind, capable of carrying 3,000 tons, might sail on a voyage so long that she would be compelled to carry 2,200 tons of coal, leaving room for only 800 tons of freight; whereas, at the present time, a steamer with the compound engines, and all other modern improvements, can make the same voyage and practically reverse the figures—that is, carry 2,200 tons of freight with a consumption of only 800 tons of coal. How, under such circumstances, the

charge for sea-freights on articles of comparatively high value has been reduced, is shown by the fact that the ocean transport of fresh meats from New York to Liverpool does not exceed 1 cent (½*d.*) per pound; and including commissions, insurance, and all other items of charge, does not exceed 2 cents (1*d.*) per pound. Boxed meats have also been carried from Chicago to London as a regular business for 50 cents per 100 pounds. In 1860 6*d.* (12 cents) per bushel was about the lowest rate charged for any length of time for the transportation of bulk grain from New York to Liverpool, and for a part of that year the rate ran up as high as 13½*d.* (27 cents) per bushel. But for the year 1886 the average rate for the same service was 2½*d.* (5 cents) per bushel. In like manner, the cost of the ocean transportation of tea from China and Japan, or sugar from Cuba, or coffee from Brazil, has been greatly reduced by the same causes.

The above are examples on a large scale of the disturbing influence of the recent application of steam to maritime industries. The following is an example drawn from comparatively one of the smallest of the world's industries, prosecuted in one of the most out-of-the-way places: The seal-fishery is a most important industrial occupation and source of subsistence to the poor and scant population of Newfoundland. Originally it was prosecuted in small sailing-vessels, and upward of a hundred of such craft, employing a large number of men, annually left the port of St. John's for the seal-hunt. Now few or no sailing-vessels engage in the business; steamers have been substituted, and the same number of seals are taken with half the number of men that were formerly needed. The consequence is, a diminished opportunity for a population of few resources, and to obtain "a berth for the ice," as it is termed, is now considered as a favor.

Is it, therefore, to be wondered at, that the sailing-vessel is fast disappearing from the ocean; that good authorities estimated in 1886 that the tonnage then afloat was about twenty-five per cent in excess of all that was needed to do the then carrying-trade of the world; and that ship-owners everywhere have been unanimously of the opinion that the depression of industry is universal?

Great, however, as has been the revolution in respect to economy and efficiency in the carrying-trade upon the ocean, the revolution in the carrying-trade upon land during the same period has been even greater and more remarkable. Taking the American railroads in general as representative of the railroad system of the world, the average charge for moving one ton of freight per mile has been reduced from about 2·5 cents in 1869 to 1·05 in 1885; or, taking the results on one of the standard roads of the United States (the New York Central) from 1·95 in 1869 to 0·68 in 1885. To grasp fully the meaning and significance of these figures, their method of presentation may be varied by saying that two thousand pounds of coal, iron, wheat, cotton, or other commodities, can now be carried on the best managed

railways for a distance of one mile, for a sum so small, that outside of China it would be difficult to find a coin of equivalent value to give to a boy as a reward for carrying an ounce package across a street, even if a man or boy could be found in Europe or the United States willing to give or accept so small a compensation for such a service.

The following ingenious method of illustrating the same results has been also suggested: The number of miles of railroad in operation in various parts of the world in 1885 was probably about 300,000. Reckoning their capacity for transportation at a rate not greater than the results actually achieved in that same year in the United States, it would appear that the aggregate railroad system of the world could easily have performed work in 1885 equivalent to transporting 120,000,000,000 tons one mile. "But if it is next considered that it is a fair day's work for an ordinary horse to haul a ton 6·7 miles, year in and year out, it further appears that the railways have added to the power of the human race, for the satisfaction of its desires by the cheapening of products, a force somewhat greater than that of a horse working twelve days yearly for every inhabitant of the globe." Less than a half a century ago, the railroad was practically unknown.* It is, therefore, within that short period that this enormous power has been placed at the disposal of every inhabitant of the globe for the cheapening of transportation to him of the products of other people and countries, and for enabling him to market or exchange to better advantage the results of his own labor or services. As the extension of the railway system has, however, not been equal in all parts of the world—less than 25,000 miles existing, at the close of 1884, in Asia, Africa, and Australia combined—its accruing benefits have not, of course, been equal. And while all the inhabitants of the globe have undoubtedly been profited in a degree, by far the greater part of the enormous additions that have been made to the world's working force through the railroad since 1840, have accrued to the benefit of the people of the United States, and of Europe—exclusive of Russia, Turkey, and the former Turkish provinces of Southeastern Europe—a number not much exceeding two hundred millions, or not a quarter part of the entire population of the globe. The result of this economic change has therefore been to broaden and deepen rather than diminish the line of separation, between the civilized and the semi-civilized and barbarous nations.

Now, while a multiplicity of inventions and of experiences have contributed to the attainment of such results under this railroad system of transportation, the discovery of a method of making *steel cheap*

* As late as 1840 there were in operation only about 2,860 miles of railway in America, and 2,130 in Europe, or a total of 4,990 miles. For practical purposes, it may therefore be said that the world's railway system did not then exist; while its organization and correspondence for doing full and efficient work must be referred to a much later period.

was the one thing which was absolutely essential to make them finally possible; inasmuch as the cost of frequently replacing rails of iron would have entailed such a burden of expenditure as to have rendered the present cheapness of railway transportation utterly unattainable. And it is most interesting to note how rapidly improvements in processes have followed the discovery of Bessemer, until, on the score of relative first cost alone, it has become economical to substitute steel for iron in railroad construction.* In 1873 Bessemer steel in England, where its price has not been enhanced by protective duties, commanded $80 per ton; in 1886 it was profitably manufactured and sold in the same country for less than $20 per ton! Within the same time the annual producing capacity of a Bessemer converter has been increased fourfold, with no increase but rather a diminution of the involved labor; and by the Gilchrist-Thomas process, four men can now make a given product of steel in the same time and with less cost of material than it took ten men ten years ago to accomplish. A ton of steel rails can now also be made with 5,000 pounds of coal, as compared with 10,000 pounds in 1868.

One of the most momentous and what may be called humanitarian results of the recent great extension and cheapening of the world's railway system and service is, that there is now no longer any occasion for the people of any country indulging in either excessive hopes or fears as to the results of any particular harvest; inasmuch as the failure of crops in any one country is no longer, as it was, no later than twenty years ago, identical with high prices of grain; the prices of cereals being at present regulated, not within any particular country, but by the combined production and comsumption of all countries made mutually accessible by railroads and steamships. Hence it is that, since 1870, years of locally bad crops in Europe have generally witnessed considerably lower prices than years when the local crops were good, and there was a local surplus for export.

In short, one marked effect of the present railroad and steamship system of transportation has been to compel a uniformity of prices for all commodities that are essential to life, and to put an end forever to what, less than half a century ago, was a constant feature of commerce, namely, the existence of local markets, with widely divergent prices for such commodities. How much of misery and starvation a locally deficient harvest entailed under the old system upon the poorer classes, through the absence of opportunity of supplying the deficiency

* The average price of iron rails in Great Britain for the year 1883 was £5 per ton. Steel rails in the same market sold in 1886 for £4.5 per ton; and the London "Economist" of June, 1887, mentions a sale of 4,500 tons of steel rails, by a Belgian company, at the equivalent of £3 16s ($18.47) per ton, deliverable at their works. Since the beginning of 1883 the manufacture of iron rails in the United States has been almost entirely discontinued, and during the years from 1883 to 1887 there were virtually no market quotations for them. The last recorded average price for iron rails was $45¼ per ton in 1882. The yearly average price of steel rails at the works in Pennsylvania for 1886 was $28¼.

through importations, is shown by the circumstance that in the English debates upon the corn laws, about the year 1840, it was estimated, upon data furnished by Mr. Tooke, in his "History of Prices," that a deficiency of one sixth in the English harvest resulted in a rise of at least 100 per cent in the price of grain; and another estimate by Davenant and King, for the close of the seventeenth century, corroborates this apparently excessive statement. The estimate of these latter authorities was as follows:

For a deficit equal to—	There will be a rise in price of—
1-10	3-10
2-10	8-10
3-10	16-10
4-10	28-10
5-10	45-10

As late as 1817, the difference in France between the highest and the lowest prices of grain in different parts of the country was 45 francs per hectolitre. In 1847 the average difference was 26 francs. Since 1870 the greatest difference at any time has not been in excess of 3·55 francs. The following table, given on German authority, and representing the price (in silver gulden per hectolitre) of grain for various periods, exhibits a like progress of price equalization between nations:

PERIOD.	England.	France.	Belgium.	Prussia.
1821–'30	10·25	7·35	6·44	5·65
1831–'40	9·60	7·61	7·31	5·27
1841–'50	9·15	7·89	7·99	6·41
1851–'60	9·40	7·84	9·65	8·07
1861–'70	8·80	8·59	9·24	7·79

For grain henceforth, therefore, the railroad and the steamship have decided that there shall be but one market—the world; and that the margin for speculation in this commodity, so essential to the well-being of humanity, shall be restricted to very narrow limits.

The world's total product of pig-iron increased slowly and regularly from 1870 to 1879, at the rate of about 2½ per cent per annum; but after 1879 production increased enormously, "until in 1883 the advance among all nations reached 182·2 per cent on the make of 1870; that of the United Kingdom being 143·0, and of other countries 239·1 per cent." (*Testimony of Sir Lothian Bell, British Commission, 1886.*) Such an increase, justified perhaps at the moment, was far in excess of the ratio of increase in the world's population, and for a term of years greatly disproportionate to any increase in the world's consumption, and finally resulted, as has been before shown (see previous paper), in an extreme depression in the business, and a remarkable fall of prices. One experience from this condition of affairs in the United States is worthy of being placed on record: For

a long time the effect of prevailing high prices for pig-iron, coupled with the influence of high protective duties imposed on the imports of foreign iron, was to maintain a large number of inferior furnaces in operation; but after 1882–'83 the most intelligent American iron-producers were compelled, as it were, to meet the stagnation and absence of profit in their business by effecting improvements in the quality of their furnaces, and undoubtedly also in their management; and with such effect that the average weekly capacity of the "anthracite" furnaces of the United States has been increased since 1883 from 220 to 264 tons, and of "bituminous" from 346 tons to 507, or to the extent of 46 per cent.

In the department of textile manufactures, investigation shows that, owing to the greater effectiveness of cotton-machinery, the manufacture of cotton-goods during recent years has also increased in a greater ratio than the increase of population; and that this increase has been going on at the rate of doubling the production in about twenty years. In the United States the doubling period of population is now about thirty-three years; in Europe, about seventy-five years; and, while in Oriental countries the doubling period is not definitely known, it is unquestionably longer than that of the United States. It would, therefore, seem certain that not only is the present product of manufactured cottons in excess of the world's present exchanging capacity, but also that, without a decrease in machinery product, the world's population must speedily increase their annual per capita consumption, if this state of things is not to continue. The report of the factory inspectors of the textile industries of Great Britain, for 1885, shows the following curious changes, consequent on improvements in machinery, to have taken place in the cotton-manufacture of Great Britain since 1874: A decrease of twenty in the whole number of cotton factories; a small increase in (throwing) spindles of 2,604,679, or 0·7 of 1 per cent (a result doubtless owing to the great improvement in the producing capacity of the spindle); an increase of 6·1 per cent in the number of persons employed; and an increase in the number of looms of 97,000, or 21 per cent. Taking all the textile industries of Great Britain into consideration, the number of hands employed in 1884, as compared with 1874, has not decreased, although the increase, 2·8 per cent, has been small in proportion to the increase in production. The number of children employed in 1884 was 34,000 less than 1874, while the number of male and female adults employed increased about 65,000; a change that implies an improvement in the social condition of the country, as well as an increased production.

The displacement of muscular labor in some of the cotton-mills of the United States, within the last ten years, by improved machinery has been from 33 to 50 per cent; and the average work of one operative working one year, in the best mills of the United States, will now, according to Mr. Atkinson, supply the annual wants of 1,600 fully

clothed Chinese, or 3,000 partially clothed East Indians. In 1840 an operative in the cotton-mills of Rhode Island, working thirteen to fourteen hours a day, turned off 9,600 yards of standard sheeting in a year; in 1886 an operative in the same mill made about 30,000 yards, working ten hours a day. In 1840 the wages were $176 a year; in 1886 the wages were $285 a year.

The United States census returns for 1880, report a very large increase in the amount of coal and copper produced during the ten previous years in this country, with a very large comparative diminution in the number of hands employed in these two great mining industries; in anthracite coal the increase in the number of hands employed having been 33·2 per cent, as compared with an increase of product of 82·7; while in the case of copper the ratios were 15·8 and 70·8, respectively. For such results, the use of cheaper and more powerful blasting agents (dynamite), and of the steam-drill, furnish an explanation. And, in the way of further illustration, it may be stated that a car-load of coal, in the principal mining districts of the United States, can now (1887) be mined, hoisted, screened, cleaned, and loaded in one half the time that it required ten years previously.

The report of the United States Commissioner of Labor for 1886 furnishes the following additional illustrations:

"In the manufacture of agricultural implements, specific evidence is submitted, showing that six hundred men now do the work that, fifteen or twenty years ago, would have required 2,145 men, a displacement of 1,545.

"The manufacture of boots and shoes offers some very wonderful facts in this connection. In one large and long-established manufactory, the proprietors testify that it would require five hundred persons working by hand processes to make as many women's boots and shoes as a hundred persons now make with the aid of machinery; a displacement of eighty per cent."

"Another firm, engaged in the manufacture of children's shoes, states that the introduction of new machinery within the past thirty years has displaced about six times the amount of hand-labor required, and that the cost of the product has been reduced one half."

"On another grade of goods, the facts collected by the agents of the Bureau show that one man can now do the work which twenty years ago required ten men."

"In the manufacture of flour there has been a displacement of nearly three fourths of the manual labor necessary to produce the same product. In the manufacture of furniture, from one half to three fourths only of the old number of persons is now required. In the manufacture of wall-paper, the best evidence puts the displacement in the proportion of one hundred to one. In the manufacture of metals and metallic goods, long established firms testify that machinery has decreased manual labor 33⅓ per cent."

The following are other notable results, gathered from other sources, in what may be termed the minor industries:

In the manufacture of jewelry, one skilled workman, paid at the rate of two and a half to three dollars per day, and working according to anti-machine methods in use a few years ago, could make up three dozen pairs of sleeve-buttons per day. Now, one boy, paid five dollars per week, and working on the most modern machinery, can make up nine thousand pairs in a day. In gold (or imitation gold) chain-making, the United States now exports the cheapest grade of such jewelry produced by machinery to Germany, where cottage hand-labor, in the same avocation, can be had for a pittance, and finds a ready sale for them as against German manufacturers.

Nothing has had a greater influence in making possible the rapidity with which certain branches of retail business are now conducted, as compared with ten years ago—more especially the sale of groceries—than the cheap and rapid production of paper bags. At the outset, these bags were all made by hand-labor; but now machinery has crowded out the hand-workers, and factories are in existence in the United States which produce millions of paper bags per week, and not unfrequently fill single orders for three millions. With machinery have also come many improvements: square bags that stand up of themselves, and need only when filled from a measure to have the top edges turned over to make the package at once ready for delivery. A purchaser can now also take his butter or lard in paper trays that are brine and grease proof; his vinegar in paper jars that are warranted not to soak for one hour; a bottle of wine wrapped in a corrugated case that would not break if he dropped it on the pavement, and his oysters in paper pails that will hold water overnight. A few years ago, to have furnished gratuitously these packages, would have been deemed extravagance; but now it is found to pay as a matter of business.

The *sobriquet* of an apothecary was formerly that of a pill-maker; but the modern apothecary no longer makes pills, except upon special prescriptions; inasmuch as scores of large manufactories now produce pills by machinery according to the standard or other formulas, and every apothecary keeps and sells them, because they are cheaper, better, and more attractive than any that he can make himself.

Certain branches of occupation formerly of considerable importance seem to be passing out of existence under the influence of recent improvements. Previous to 1872, nearly all the calicoes of the world were dyed or printed with a coloring principle extracted from the root known as "*madder*"; the cultivation and preparation of which involved the use of thousands of acres of land in Holland, Belgium, Eastern France, Italy, and the Levant, and the employment of many hundreds of men, women, and children, and of large amounts of capital; the importation of madder into England for the year 1872 having been 28,731,600 pounds, and into the United States for the

same year 7,786,000 pounds. To-day, two or three chemical establishments in Germany and England, employing but few men and a comparatively small capital, manufacture from coal-tar, at a greatly reduced price, the same coloring principle; and the former great business of growing and preparing madder—with the land, labor, and capital involved—is gradually becoming extinct; the importations into Great Britain for the year 1885 having declined to 2,472,000 pounds, and into the United States to 1,458,313 pounds.

The old-time art of making millstones—entitled to rank among the very first of labor-saving inventions at the very dawn of civilization—is rapidly passing into oblivion, because millstones are no longer necessary or economical for grinding the cereals. The steel roller produces more and better flour in the same time at less cost, and as an inevitable consequence is rapidly taking the place of the millstone in all countries that know how to use machinery. And, as the art of skillfully grooving the surface of a hard, flinty rock for its conversion into a millstone is so laborious, so difficult of accomplishment (four or five years of service being required in France from an apprentice before he is allowed to touch a valuable stone), and to a certain extent so dangerous from the flying particles of steel and stone, humanity, apart from all economic considerations, may well rejoice at its desuetude.

With the substitution of steamers for sailing-vessels upon the broad ocean, the former extensive business of sail-making, and the demand upon factories for heavy cloth as material for sails, experienced a notable depression, which in later years has continued and increased, because commerce along coast-lines also now no longer moves exclusively by sail, but largely in barges dragged or propelled by steam. For the four years next previous to 1886, the demand for sails in the United States is estimated to have decreased to the extent of about twenty-five per cent, although the carrying-trade of the country by ocean, coast, and inland waters, has, during the same time, increased very considerably.

Cotton-seed oil—an article a few years ago absolutely unknown in commerce, and prepared from what was formerly regarded almost in the light of a waste product, is now manufactured in the United States, and has come into such extensive use as a substitute for lard, olive, and other oils, for culinary and manufacturing purposes, that its present annual production and sale are estimated to be equivalent to about 70,000,000 pounds of lard; and has contributed not only to reduce notably the price and the place of that important hog-product in the world's markets, but also to impair the production and depress the price of almost all other vegetable oils—the product of the industries of other countries.

But in respect to no other one article has change in the conditions of production and distribution been productive of such momentous

consequences as in the case of wheat. On the great wheat-fields of the Territory of Dakota, where machinery is applied to agriculture to such an extent that the requirement for manual labor has been reduced to a minimum, the annual product of one man's labor, working to the best advantage, is understood to be now equivalent to the production of 5,500 bushels of wheat. In the great mills of Minnesota, the labor of another one man for a year, under similar conditions as regards machinery, is in like manner equivalent to the conversion of this unit of 5,500 bushels of wheat into a thousand barrels of flour, leaving 500 bushels for seed-purposes; and although the conditions for analysis of the next step in the way of results are more difficult, it is reasonably certain that the year's labor of one and a half men more—or at the most two men—employed in railroad transportation, is equivalent to putting this thousand barrels of flour on a dock in New York ready for exportation; where the addition of a fraction of a cent a pound to the price will further transport and deliver it at almost any port of Europe.*

Here, then, we have the labor of three men for one year, working with machinery, resulting in producing all the flour that a thousand other men ordinarily eat in a year, allowing one barrel of flour for the average consumption of each adult. Before such a result the question of wages paid in the different branches of flour production and transportation becomes an insignificant factor in determining a market; and, accordingly, American flour grown in Dakota, and ground in Minneapolis, from a thousand to fifteen hundred miles from the nearest seaboard, by the labor of men paid from a dollar and a half to two dollars and a half per day for their labor, is sold in European markets at rates which are determinative of the prices which Russian peasants, Egyptian "fellahs," and Indian "ryots" can obtain in the same markets for similar grain grown by them on equally good soil, and with from fifteen to twenty cents per day wages for their labor.

A great number of other similar and equally remarkable experiences, derived from almost every department of industry except the handicrafts, might be presented; but it would seem that enough evidence has been offered to prove abundantly that, in the increased con-

* When the wheat reaches New York city, and comes into the possession of a great baker, who has established the manufacture of bread on a large scale, and who sells the best of bread to the working-people of New York at the lowest possible price, we find that one thousand barrels of flour can be converted into bread and sold over the counter by the work of three persons for one year. Let us add to the six and a half men already named the work of another man six months, or a half a man one year, to keep the machinery in repair, and our modern miracle is, that seven men suffice to give one thousand persons all the bread they customarily consume in one year. If to these we add three for the work of providing fuel and other materials to the railroad and the baker, our final result is that ten men working one year serve bread to one thousand."—*Distribution of Products*, EDWARD ATKINSON.

trol which mankind has acquired over the forces of Nature, and in the increased utilization of such control—mainly through machinery—for the work of production and distribution, is to be found a cause amply sufficient to account for the economic disturbance, which, since the year 1873, has been certainly universal in its influence over the domain of civilization, abnormal to the extent of justifying the claim of having been unprecedented in character, and which bids fair in a greater or less degree to continue indefinitely. Other causes may and doubtless have contributed to such a condition of affairs, but in this one cause alone (if the influences referred to can be properly considered as a unity) there has been sufficent of potentiality to account not only for all the economic phenomena that are under discussion, but to occasion a feeling of wonder that the world has accommodated itself so readily to the extent that it has to its new conditions, and that the disturbances have not been very much greater and more disastrous.

A question which these conclusions will naturally suggest may at once be anticipated. Have not these same influences, it may be asked, been exerted during the whole of the present century, and in fact ever since the inception of civilization; and are there any reasons for supposing that this influence has been different during recent years in kind and degree from what has been heretofore experienced? The answer is, Certainly in kind, but not in degree. The world has never seen anything comparable to the results of the recent system of transportation by land and water, never experienced in so short a time such an expansion of all that pertains to what is called business, and has never before, as was premised at the outset of this argument, been able to accomplish so much in the way of production with a given amount of labor in a given time. Thus it is claimed in respect to the German Empire, where the statistics of production and distribution have doubtless been more carefully studied by experts than elsewhere, that during the period from 1872 to 1885 there was an expansion in the railroad traffic of the empire of ninety per cent; in maritime tonnage, of about a hundred and twenty per cent; in the general mercantile or commercial movement, of sixty-seven per cent; in postal matter carried, of a hundred and eight per cent; in telegraphic dispatches, of sixty-one per cent; and in bank discounts, of two hundred and forty per cent. During the same period population increased about eleven and a half per cent; and from such data there has been a general deduction that, "if one unit of trade was the ratio to one unit of population in Germany in 1872, the proportion in 1885 was more than ten units of trade to one of population." But, be this as it may, it can not be doubted that whatever has been the industrial expansion of Germany in recent years, it has been at least equaled by England, approximated to by France, and certainly surpassed by the United States.

There is very much that contributes to the support of the idea

which has been suggested by M. Laveleye, editor of the "Moniteur des Intérêts Matériels," at Brussels, that the industrial activity of the greater part of this century has been devoted to equipping fully the civilized countries of the world with economic tools, and that the work of the future, in this same sphere, must be necessarily that of repair and replacements rather than of new constructions. But a more important inference from this same idea, and one that fully harmonizes with and rationally explains the phenomena of the existing situation is, that the equipment having at last been made ready, the work of using it for production has in turn begun, and has been prosecuted so efficiently, that the world has within recent years, and for the first time, become saturated, as it were, under existing conditions for use and consumption, with the results of these modern improvements. Again, although the great natural labor-saving agencies had been recognized and brought into use many years prior to 1870, their powers were long kept, as it were, in abeyance; because it required time for the instrumentalities or methods by which the world's work of production and distribution was carried on to adjust themselves to new conditions; and until this was accomplished, an almost infinite number and variety of inventions which genius had produced for facilitating and accelerating industrial evolution were matters of promise, rather than of consummation. But with the extension of popular education and the rapid diffusion of intelligence, all new achievements in science and art have been brought in recent years so much more rapidly "within the sphere of the every-day activity of the people"—as the noted German inventor, Dr. Werner Siemens, has expressed it—"that stages of development, which ages ago required centuries for their consummation, and which at the beginning of our times required decades, now complete themselves in years, and not unfrequently present themselves at once in a state of completeness."

An influence which has been more potent in recent years than ever before in stimulating the invention and use of labor-saving machinery, and one which should not be overlooked in reasoning upon this subject, has been undoubtedly the increasing frequency of strikes and industrial revolts on the part of the large proportion of the population of all civilized countries engaged in the so-called mechanical occupations, which actions in turn on the part of such classes have been certainly largely prompted by the changes in the conditions of production resulting from prior labor-saving inventions and discoveries. As the London "Engineer" has already pointed out (see page 291, article No. 1), the remedy that at once suggests itself to every employer of labor on the occasion of such trouble with his employés is "to use a tool wherever it is possible instead of a man." A significant illustration of the quickness with with employers carry out this suggestion, is afforded by the well-authenticated fact that the strike among the boot and shoe factories of one county in the State of Mas-

sachusetts in the year 1885, resulted in the capacity for producing by the same factories during the succeeding year of a fully equal product, with reduction of at least fifteen hundred operatives; one machine improvement for effecting an operation called "lasting" having been introduced, which is capable of doing the former work of from two hundred to two hundred and fifty men with a force not exceeding fifty men.

Another fact confirmatory of the above conclusions, is that all investigators seem to be agreed that the depression of industry in recent years has been experienced with the greatest severity in those countries where machinery has been most largely adopted, and least, or almost not at all, in those countries and in those occupations where hand-labor and hand-labor products have not been materially interfered with or supplanted. There is no evidence that the mass of the people of any country removed from the great lines of the world's commerce, as in China, India, Turkey, Mexico, and the states of Northern Africa, have experienced any economic disturbance prior to 1883, except from variations in crops, or civil commotions; and if the experience of a few of such countries has been different since 1883, the causes may undoubtedly be referred to the final influence of long-delayed extraneous disturbances, as has been the case in Mexico, in respect to the universal depreciation of silver,* and in Japan, from an apparent culmination of a long series of changes in the civilization and economy of that country. There have, moreover, been no displacements of labor or reduction in the cost of labor or product in all those industries in civilized countries, where machinery has not been increased; as, for example, in domestic service, in such departments of agriculture as the raising and care of stock, the growing of cotton, of flax, hemp, and of tropical fibers of like character, or in such mechanical occupations as masonry, painting, upholstering, plastering, and cigar-making, or those of engineers, firemen, teamsters, watchmen, and the like.

Finally, it is of the first importance to note how all the other causes which have been popularly regarded as having directly occasioned, or essentially contributed to, the recent depression of trade and industry —with the exception of such as are in the nature of natural phenomena, as bad seasons and harvests, diseases of plants and animals, disappearance of fish, and the like, and such as are due to excessive taxation, consequent on war expenditures, all of which are local, and the first temporary in character—naturally group themselves about the one great cause that has been suggested, as sequences or derivatives, and as secondary rather than primary in their influence; and to the facts and deductions that are confirmatory of this conclusion attention will be next invited.

* The average rate of exchange in Mexico on London fell from 41 to 46 per dollar in the early months of 1885 to 38 to 76 in the spring of 1886.

NEW CHAPTERS IN THE WARFARE OF SCIENCE.

By ANDREW DICKSON WHITE,
LATE PRESIDENT OF CORNELL UNIVERSITY.

III.—METEOROLOGY (*concluded*).

WHILE the Fathers and school-men were laboring to deduce a science of meteorology from our sacred books, there oozed up in European society a mass of traditions and observances which had been lurking since the days of paganism; and, although here and there appeared a churchman to oppose them, the theologians and ecclesiastics ere long began to adopt them and to clothe them with the authority of religion.

Both among the pagans of the Roman Empire and among the barbarians of the North the Christian missionaries had found it easier to prove the new God supreme than to prove the old gods powerless. Faith in the miracles of the new religion seemed to increase rather than to diminish faith in the miracles of the old; and the Church at last began admitting the latter as facts, but ascribing them to the devil. Jupiter and Odin sank into the category of ministers of Satan, and transferred to that master all their former powers. A renewed study of Scripture by the theologians, in the light of this hypothesis, elicited overwhelming proofs of its truth. They found very many sacred texts to support it, and it soon became a dogma. So strong was the hold it took, under the influence of the Church, that not until late in the seventeenth century did its substantial truth begin to be questioned.

Now, with no field of action had the sway of the ancient deities been more identified than with that of atmospheric phenomena. The Roman heard Jupiter, and the Teuton heard Thor, in the thunder. Could it be doubted that these powerful beings would now take occasion, unless hindered by the command of the Almighty, to vent their spite against those who had deserted their altars? Might not the Almighty himself be willing to employ the malice of these powers of the air against those who had offended him?

It was, indeed, no great step, for those whose simple faith accepted rain or sunshine as an answer to their prayers, to suspect that the untimely storms or droughts, which baffled their most earnest petitions, were the work of the arch-enemy, "the prince of the power of the air."

The great Fathers of the Church had laid the basis of this doctrine in Scripture. Saint Jerome declared the air to be full of devils, basing this belief upon various statements in the prophecies of Isaiah and in

the Epistle to the Ephesians.* Saint Augustine held the same view as beyond controversy.†

During the middle ages this doctrine of the diabolical origin of storms went on gathering strength. Bede had full faith in it, and narrates various anecdotes in support of it.‡ Saint Thomas Aquinas gave it his sanction, saying in his all-authoritative "Summa": "Rains and winds, and whatsoever occurs by local impulse alone, can be caused by demons." "It is," he says, "a dogma of faith that the demons can produce wind, storms, and rain of fire from heaven."*

Albert the Great taught the same doctrine, and showed how a certain salve thrown into a spring produced whirlwinds.‖ The great Franciscan—the "seraphic doctor"—Saint Bonaventura, whose services to theology earned him one of the highest places in the Church, and to whom Dante gave special honor in paradise, set upon this belief his high authority.△ The lives of the saints, and the chronicles of the middle ages, were filled with it. Poetry and painting accepted the idea and developed it. Dante wedded it to verse,◊ and at Venice this thought may still be seen embodied in one of the grand pictures of Bordone: a ship-load of demons is seen approaching Venice in a storm, threatening destruction to the city, but Saint Mark, Saint George, and Saint Nicholas attack the vessel, and disperse the hellish crew.‡

The popes again and again sanctioned this doctrine, and it was amalgamated with various local superstitions, pious imaginations, and interesting arguments, to strike the fancy of the people at large. A strong argument in favor of a diabolical origin of the thunderbolt was afforded by the eccentricities of its operation. These attracted especial attention in the middle ages, and the popular love of marvel generalized isolated phenomena into rules. Thus, it was said that the lightning strikes the sword in the sheath, gold in the purse, the foot in the shoe, leaving sheath, and purse, and shoe unharmed; that it consumes a human being internally without injuring the skin; that it destroys

* Thus, in his "Com. in Epist. ad Ephesios" (iii, 6), commenting on the text, "Our battle is not with flesh and blood," he explains this as meaning the devils in the air; and adds: "Nam et in alio loco de dæmonibus quod in aere isto vagentur, Apostolus ait: In quibus ambulastis aliquando juxta sæculum mundi istius, secundum principem potestatis aeris spiritus, qui nunc operatur in filios diffidentiæ" (Ephes. ii, 2). "Hæc autem omnium doctorum opinio est, quod aer iste qui cœlum et terram medius dividens, inane appellatur, plenus sit contrariis fortitudinibus." See also his "Com. in Isaiam," xiii, 50 (Migne, "Patr. Lat.," xxiv, 477).

† As to Augustine, see the "De Civitate Dei," *passim*.

‡ See Bede, "Hist. Eccles.," i, 17; "Vita Cuthberti," c. 17.

* See Thomas Aquinas, "Summa," pars I, qu. lxxx, art. 2, cited by Maury, "Légendes Pieuses," 11. The second citation I owe to Rydberg, "Magic of the Middle Ages," 73, where the whole interesting passage is given at length.

‖ See Albertus Magnus, "De Potentia Dæmonum" (cited by Maury, as above).

△ See Bonaventura, "Comp. Theol. Veritat.," ii, 26.

◊ See Dante, "Purgatorio," c. 5.

‡ See Maury, "Légendes Pieuses," 18, note.

nets in the water, but not on the land; that it kills one man, and leaves untouched another standing beside him; that it can tear through a house and enter the earth without moving a stone from its place; that it injures the heart of a tree, but not the bark; that wine is poisoned by it, while poisons struck by it lose their venom; that a man's hair may be consumed by it, and the man be unhurt.*

These peculiar phenomena, made much of by the allegorizing sermonizers of the day, were used in moral lessons from every pulpit. Thus, the Carmelite, Matthias Farinator, of Vienna, who at the pope's own instance compiled early in the fifteenth century that curious handbook of illustrative examples for preachers, the "Lumen Animæ," finds a spiritual analogue for each of these anomalies.†

This doctrine grew robust and noxious, until, in the fifteenth, sixteenth, and seventeenth centuries, we find its bloom in a multitude of treatises by the most learned of the Catholic and Protestant divines, and its fruitage in the torture-chambers and on the scaffolds throughout Christendom. At the Reformation period, and for nearly two hundred years afterward, Catholics and Protestants vied with each other in promoting this growth. John Eck, the great opponent of Luther, gave to the world an annotated edition of Aristotle's "Physics," which was long authoritative in the German universities; and, though the text is free from this doctrine, the woodcut illustrating the earth's atmosphere shows most vividly, among the clouds of mid-air, the devils who there reign supreme.‡

Luther, in the other religious camp, supported the superstition even more zealously, asserting at times his belief that the winds themselves are only good or evil spirits,* and declaring that he had himself calmed more than twenty storms caused by the devil.‖

Just at the close of the same century, Catholics and Protestants hailed alike the great work of Delrio.^ In this the power of devils over the elements is proved first from the Holy Scriptures, since, he declares, "they show that Satan brought fire down from heaven to consume the servants and flocks of Job, and that he stirred up a violent wind, which overwhelmed in ruin the sons and daughters of Job at their feasting"; next, Delrio insists on the agreement of all the orthodox Fathers that it was the devil himself who did this, and attention is called to the fact that the hail with which the Egyptians were punished is expressly declared in Holy Scripture to have been brought

* See, for lists of such *admiranda*, any of the early writers—e. g., Vincent of Beauvais, Reisch's "Margarita," or Eck's "Aristotle."

† See the "Lumen Animæ," Eichstadt, 1479.

‡ See Eck, "Aristotelis Meteorologica," Augsburg, 1519.

* See his "Memoirs," iii, 172 (cited by Maury, "Légendes Pieuses," 18).

‖ See his "Memoirs," p. 190 (cited by Maury, as above, p. 18).

^ His "Disquisitiones Magicæ," first printed at Liége in 1599–1600 (in three vols. 4to), but reprinted again and again throughout the seventeenth century.

by the evil angels.* Citing from the Apocalypse, he points to the four angels standing at the fourcorners of the earth, holding back the winds and preventing their doing great damage to mortals ;† and he dwells especially upon the fact that the devil is called by the apostle a "prince of the power of the air."‡ He then goes on to cite the great Fathers of the Church, Clement, Jerome, Augustine, and Thomas Aquinas.*

This doctrine was spread, not only in ponderous treatises, but in light literature, and by popular illustrations. In the "Compendium Maleficarum" of the Italian monk Guacci, perhaps the most amusing book in the whole literature of witchcraft, we may see the witch, *in propria persona*, riding the diabolic goat through the clouds while the storm rages around and beneath her ; and we may read a rich collection of anecdotes, largely contemporary, which establish the required doctrine beyond question.‖

The first and most natural means taken against this work of Satan in the air, was Prayer ; and various petitions are to be found scattered through the Christian liturgies—some very beautiful and touching. This means of escape has been relied upon, with greater or less faith, from those days to these. Various mediæval saints and reformers, and devoted men in all centuries, from Saint Giles to John Wesley, have used it with results claimed to be miraculous.^ Whatever theory any thinking man may hold in the matter, he will certainly not venture a reproachful word : such prayers have been in all ages a natural outcome of the mind of man in trouble.

But against the "powers of the air" were used other means of a very different character and tendency, and foremost among these was Exorcism. In an exorcism widely used and ascribed to Pope Gregory XIII, the formula is given : "I, a priest of Christ, . . . do command ye, most foul spirits, who do stir up these clouds, . . . that ye depart from them, and disperse yourselves into wild and untilled places, that ye may be no longer able to harm men or animals or fruits or herbs or whatsoever is designed for human use." But this is mild, indeed, compared to some later exorcisms, as when the ritual runs : "All the people shall rise, and the priest, turning toward the clouds, shall pronounce these words : 'I exorcise ye, accursed demons, who have dared to use, for the accomplishment of your iniquity, those powers of Nature

* This interpretation of Psalm lxxviii, 47–49, was apparently shared by the translators of our own authorized version.

† Revelation, vii, 1.

‡ Ephesians, ii, 2. Even according to modern commentators (e. g. Alford) the word here translated "power" denotes, not *might*, but *government, court, heirarchy ;* and in this sense it was always used by the ecclesiastical writers, whose conception is best rendered by our plural—"powers."

* See Delrio, "Disquisitiones Magicæ," lib. ii, c. 11.

‖ See Guacci, "Compendium Maleficarum" (Milan, 1606).

^ For the cases of Saint Giles, John Wesley, and others stilling the tempests, see Brewer, "Dictionary of Miracles," s. v. "Prayer."

by which God in divers ways worketh good to mortals; who stir up winds, gather vapors, form clouds, and condense them into hail. . . . I exorcise ye, . . . that ye relinquish the work ye have begun, dissolve the hail, scatter the clouds, disperse the vapors, and restrain the winds.'" The rubric goes on to order that then there shall be a great fire kindled in an open place, and that over it the sign of the cross shall be made, and the one hundred and fourteenth Psalm chanted, while malodorous substances, among them sulphur and asafœtida, shall be cast into the flames. The purpose seems to have been literally to "smoke out" Satan.*

Manuals of exorcisms became important—some bulky quartos, others hand-books. Noteworthy among the latter is one by the Italian priest Locatelli, entitled "Exorcisms most Powerful and Efficacious for the Dispelling of Aërial Tempests, whether raised by Demons at their own Instance or at the Beck of some Servant of the Devil." †

The Jesuit Gretser, in his famous book on "Benedictions and Maledictions," devotes a chapter to this subject, dismisses summarily the skepticism that questions the power of devils over the elements, and adduces the story of Job as conclusive.‡

Nor was this theory of exorcism by any means confined to the elder Church. Luther vehemently upheld it, and prescribed especially the first chapter of St. John's gospel as of unfailing efficacy against thunder and lightning, declaring that he had often found the mere sign of the cross, with the text, "The word was made flesh," sufficient to put storms to flight.*

From the beginning of the middle ages until long after the Reformation, the chronicles give ample illustration of the successful use of such exorcisms. So strong was the belief in them that it forced itself into minds comparatively rational, and found utterance in treatises of much importance.

But, since exorcisms were found at times ineffectual, other means were sought, and especially Fetiches of various sorts. One of the earliest of these appeared when Pope Alexander I, in the second century, ordained that holy-water should be kept in churches and bedchambers to drive away devils.‖ Another safeguard was found in relics, and

* See Polidorus Valerius, "Practica exorcistarum"; also the "Thesaurus exorcismorum" (Cologne, 1626), 158–162.

† That is, "Exorcismi," etc. A "corrected" second edition was printed at Laybach, 1680, in 24mo, to which is appended another manual of "Preces et conjurationes contra aëreas tempestates, omnibus sacerdotibus utiles et necessaria," printed at the monastery of Kempten (in Bavaria) in 1667. The latter bears as epigraph the passage from the gospels describing Christ's stilling of the winds.

‡ See Gretser, "De benedictionibus et maledictionibus," lib. ii, c. 48.

* See Gretser, as above.

‖ "Instituit ut aqua quam sanctam appellamus sale admixta interpositis sacris orationibus et in templis et in cubiculis ad fugandos dæmones retineretur."—Platina, "Vitæ Pontif.," s. v. Alexander (108–117 A. D.).

of similar efficacy were the so-called "conception billets" sold by the Carmelite monks. They contained a formula upon consecrated paper, at which the devil might well turn pale. Buried in the corner of a field, one of these was thought to give protection against bad weather and destructive insects.*

But highest in repute during centuries was the *Agnus Dei*—a piece of wax blessed by the pope's own hand, and stamped with the well-known device representing the "Lamb of God."† Its powers were so marvelous that Pope Urban V thought three of them a fitting gift from himself to the Greek emperor. In the Latin doggerel recounting their virtues, their meteorological efficacy stands first, for especial stress is laid on their power of dispelling the thunder. This stress thus laid by Pope Urban, as the infallible guide of Christendom, on the efficacy of this fetich, gave it great value throughout Europe, and the doggerel verses reciting its virtues sank deep into the popular mind.‡ It was considered a most potent means of dispelling hail, pestilence, storms, conflagrations, and enchantments; and this feeling was deepened by the rules and rites for its consecration.* So solemn was the matter, that the manufacture and sale of this particular fetich was, by a papal bull of 1471, reserved for the pope himself,‖ and he only performed the required ceremony in the first and seventh years of his pontificate. Standing unmitred, he prayed: "O God, . . . we humbly beseech thee that thou wilt bless these waxen forms, figured with the image of an innocent lamb, . . . that, at the touch and sight of them, the faithful may break forth into praises, and that the crash of hailstorms, the blast of hurricanes, the violence of tempests, the fury of winds, and the malice of thunderbolts may be tempered, and evil spirits flee and tremble before the standard of thy holy cross, which is graven upon them."△

* See Rydberg, "The Magic of the Middle Ages," translated by Edgren, pp. 64–66.

† They are still in use in the Church, and may be found described in any ecclesiastical cyclopædia.

‡ "Tonitrua magna terret,
Et peccata nostra delet;
Ab incendio præservat,
A submersione servat,
A morte cita liberat,
Et Cacodæmones fugat,
Inimicos nostros domat,
Prægnantem cum partu salvat,
Dona dignis multa confert,
Utque malis mala defert.
Portio, quamvis parva sit,
Ut magna tamen proficit."

See these verses cited in full faith, so late as 1743, in Father Vincent of Berg's "Enchiridium," pp. 23, 24, where is a full account of the virtues of the *Agnus Dei*, and instructions for its use.

* A full account of these rites, with the consecrating prayers and benedictions which gave color to this theory of the powers of the *Agnus Dei*, may be found in the ritual of the Church. I have used the edition entitled "Sacrarum ceremoniarum sive rituum Sanctæ Romanæ Ecclesiæ libri tres," Rome, 1560, in folio.

‖ See Rydberg, "Magic of the Middle Ages," p. 63.

△ "Deus, . . . te suppliciter deprecamur, ut . . . has cereas formas, innocentissimi agni imagine figuratas, benedicere . . . digneris, ut per ejus tactum et visum fideles in-

Another favorite means with the clergy of the older Church, for bringing to naught the powers of the air, was found in great Processions, bearing statues, relics, and holy emblems through the streets.* Yet, even these were not always immediately effective. One at Liége, in the thirteenth century, thrice proved unsuccessful in bringing rain, when at last it was found that the image of the Virgin had been forgotten! A new procession was at once formed, the *Salve Regina* sung, and the rain came down in such torrents as to drive the devotees to shelter.†

In Catholic lands this custom remains to this day, and very important features in these processions are the statues and reliquaries of patron saints. Some of these excel in bringing sunshine, others in bringing rain. The Cathedral of Chartres is so fortunate as to possess sundry relics of Saint Taurin, especially potent against dry weather, and some of Saint Piat, very nearly as infallible against wet weather.‡ In certain regions a single saint gives protection alternately against wet and dry weather—as, for example, Saint Godeberte at Noyon.* Against storms Saint Barbara is very generally considered the most powerful protectress; but, in the French diocese of Limoges, Notre Dame de Crocq has proved a most powerful rival, for when, a few years since, all the neighboring parishes were ravaged by storms, not a hailstone fell in the canton which she protected. In the diocese of Tarbes, Saint Exupère is especially invoked against hail, peasants flocking from all the surrounding country to his shrine.‖

But the means of baffling the powers of the air which came to be most widely used was the ringing of consecrated Church-Bells.

This usage had begun in the time of Charlemagne, and there is extant a prohibition of his against the custom of baptizing bells and of hanging certain tags △ on their tongues as a protection against hail-storms; but even Charlemagne was powerless against this current of mediæval superstition. Theological reasons were soon poured into it, and, about the year 970, Pope John XIII is said to have baptized a bell in the Lateran, christening it with his own name, to have stood sponsor

vitentur ad laudes, fragor grandinum, procella turbinum, impetus tempestatum, ventorum rabies, infesta tonitrua temperentur, fugiant atque tremiscant maligni spiritus ante Sanctæ Crucis vexillum, quod in illis exsculptum est. . . ." ("Sacr. Cer. Rom. Eccl.," as above.) If any are curious as to the extent to which this consecrated wax was a specific for all spiritual and most temporal ills during the sixteenth and seventeenth centuries, let them consult the Jesuit "Litteræ annuæ," *passim*.

* John of Winterthur describes many such in Switzerland in the thirteenth century, and all the monkish chronicles speak of them.

† See Rydberg, "Magic of the Middle Ages," p. 74.

‡ See the "Guide du touriste et du pèlerin à Chartres," 1867 (cited by "Paul Parfait," in his "Dossier des Pèlerinages").

* See "Paul Parfait," as above, p. 139.

‖ See "Paul Parfait," as above, p. 145.

△ "Perticæ." See Montanus, "Hist. Nachricht von den Glocken" (Chemnitz, 1726), p. 121; and Meyer, "Der Aberglaube des Mittelalters," p. 186.

for one of the bells of St. Peter's, and to have issued a bull for the baptizing of bells "to cleanse the air of devils."*

This idea was rapidly developed, and we soon find it supported in ponderous treatises, spread widely in sermons, and popularized in multitudes of inscriptions cast upon the bells themselves. This branch of theological literature may still be studied in multitudes of church-towers throughout Europe. A bell at Basel bears the inscription, "Ad fugandos demones." Another, in Lugano, declares "The sound of this bell vanquishes tempests, repels demons, and summons men." Another, at the Cathedral of Erfurt, declares that it can "ward off lightning and malignant demons."† A peal in the Jesuit church at the university town of Pont-à-Mousson bore the words, "They praise God, put to flight the clouds, affright the demons, and call the people." This is dated 1634. Another bell in that part of France declares, "It is I who dissipate the thunders" (*Ego sum qui dissipo tonitrua*).‡

Another, in one of the forest cantons of Switzerland, bears a doggerel couplet, which may be thus translated:

> "On the devil my spite I'll vent,
> And, God helping, bad weather prevent."*

Very common were inscriptions embodying this doctrine in sonorous Latin.

In accordance with this doctrine, there grew up a ritual for the consecration of bells. Knollys, in his translation of the quaint old chronicler Sleidan, gives us the usage in the simple English of the middle of the sixteenth century:

"In lyke sorte [as churches] are the belles used. And first, forsouth, they must hange so, as the Byshop may goe round about them. Whiche after he hath sayde certen Psalmes, he consecrateth water and salte, and mingleth them together, wherwith he washeth the belle diligently both within and without, after wypeth it drie, and with holy oyle draweth in it the signe of the crosse, and prayeth God, that whan they shall rynge or sounde that bell, all the disceiptes of the devyll may vanyshe away, hayle, thondryng, lightening, wyndes, and tempestes, and all untemperate weathers may be aswaged. Whan he hath wipte out the crosse of oyle wyth a linen cloth, he maketh seven other crosses in the same, and within one only. After saying certen Psalmes, he taketh a payre of sensours and senseth the bel within, and

* Such is the current statement (see, e. g., Higgins's "Anacalypsis," ii, 70), but I am unable to find satisfactory record of this bull. Platina relates only ("Vitæ Pontif." s. v. John XIII) that this pope stood sponsor for a bell of St. Peter's.

† These illustrations, with others equally striking, may be found in Meyer, "Der Aberglaube des Mittelalters," 185, 186.

‡ For these two instances and many more, see Germain, "Anciennes cloches lorraines" (Nancy, 1885), pp. 23, 27.

* "An dem Tüfel will ich mich rächen,
Mit der hilf gotz alle bösen wetter zerbrechen."
(See Meyer, as above.)

prayeth God to sende it good lucke. In many places they make a great dyner, and kepe a feast as it were at a solemne wedding."*

These bell baptisms became matters of great importance. Popes, kings, and prelates were proud to stand as sponsors. During the French Revolution, four of the bells at the Cathedral of Versailles were destroyed; and on the 6th of January, 1824, four new ones were baptized, the Voltairian, King Louis XVIII, and the pious Duchess d'Angoulême standing as sponsors.

In some of these ceremonies, zeal appears to have outrun knowledge, and one of Luther's stories, at the expense of the older Church, was that certain authorities thus christened a bell "Hosanna," supposing that to be the name of a woman.

To add to the efficacy of such baptisms, water was sometimes brought from the river Jordan.†

The prayers used at bell baptisms fully recognize this doctrine; the ritual of Paris embraces the petition that "whensoever this bell shall sound, it shall drive away the malign influences of the assailing spirits, the horror of their apparitions, the rush of whirlwinds, the stroke of lightning, the harm of thunder, the disasters of storms, and all the spirits of the tempest."‡ Another prayer begs that "the sound of this bell may put to flight the fiery darts of the enemy of men";* and others vary the form but not the substance of this petition. The great Jesuit theologian, Bellarmin, did indeed try to deny the reality of this baptism; but this can only be regarded as a piece of casuistry suited to Protestant hardness of heart, or as strategy in the warfare against heretics.

Forms of baptism were laid down in various manuals sanctioned directly by papal authority, and sacramental efficacy was everywhere taken for granted.‖ The development of this idea in the older Church was too strong to be resisted;△ but, as a rule, the Protestant theolo-

* Sleidan's "Commentaries," English translation, as above, fol. 334 (lib. xxi, sub anno 1549).

† See Montanus, as above, who cites Beck, "Lutherthum vor Luthero," p. 294, for the statement that many bells were carried to the Jordan by pilgrims for this purpose.

‡ See Arago, "Œuvres" (Paris, 1854), vol. iv, p. 322.

* Arago, as above.

‖ As has often been pointed out, the ceremony was in all its details—even to the sponsors, the wrapping a garment about the baptized, the baptismal fee, the feast—precisely the same as when a child was baptized. Magius, who is no skeptic, relates, from his own experience, an instance of this sort, where a certain bishop stood sponsor for two bells, giving them both his own name—William (see his "De Tintinnabulis," xiv).

△ And no wonder, when the oracle of the Church, Thomas Aquinas, expressly pronounced church-bells, "provided they have been duly consecrated and baptized," the foremost means of "frustrating the atmospheric mischiefs of the devil," and likened steeples in which bells are ringing to a hen brooding her chickens, "for the tones of the consecrated metal repel the demons and avert storm and lightning"; when pre-Reformation preachers of such universal currency as Joannes Herolt could declare, "Bells, as all agree, are baptized with the result that they are secure from the power of Satan,

gians of the Reformation, while admitting that storms were caused by Satan and his legions, opposed the baptism of bells, and denied the theory of their influence in dispersing storms.* Luther, while never doubting that troublesome meteorological phenomena were caused by devils, regarded with contempt the idea that the demons were so childish as to be scared by the clang of bells; his theory of diabolic power made them altogether too powerful to be affected by means so trivial. The great English reformers, while also accepting very generally the theory of diabolic interference in storms, reproved strongly the baptizing of bells, as the perversion of a sacrament, and involving blasphemy. Bishop Hooper declared reliance upon bells to drive away tempests, futile;† Bishop Pilkington, while arguing that tempests are direct instruments of God's wrath, is very severe against using "unlawful means," and among these he names "the hallowed bell";‡ and these opinions were very generally shared by the leading English clergy.*

Toward the end of the sixteenth century the Elector of Saxony strictly forbade the ringing of bells against storms, urging penance and prayer instead;‖ but the custom was not so easily driven out of the Protestant Church, and in some quarters was developed a Protestant theory of a rationalistic sort—ascribing the good effects of bell-ringing in storms to the calling together of the devout for prayer or to the suggestion of prayers during storms at night.△ As late as the end of the seventeenth century we find the bells of Protestant churches in Northern Germany rung for the dispelling of tempests.◊ In Catholic Austria this bell-ringing seems to have become a nuisance in the last century, for the Emperor Joseph II found it necessary to issue an edict against it; but this doctrine had gained too large headway to be arrested by argument or edict, and the bells may be heard ringing during storms to this day in various remote districts in Europe.

For this was no mere superficial view. It was really part of a deep

terrify the demons, compel the powers"; and when a canonist like Durandus explained the purpose of the rite to be, that "the demons hearing the trumpets of the Eternal King, to wit, the bells, may flee in terror, and may cease from the stirring up of tempests." (See Herolt, "Sermones Discipuli," xvii, and Durandus, "De ritibus ecclesiæ," ii, 12.) (I owe the first of these citations to Rydberg, and the others to Montanus.)

* The baptism of bells was, indeed, one of the express complaints of the German Protestant princes at the Reformation. See their "Gravam. Cent. German. Grav.," 51.

† See his "Early Writings," 197 (in "Parker Society Publications").

‡ See his "Works," 177 (in "Parker Society Publications").

* E. g., by Tyndale, Bishop Ridley, Archbishop Sandys, Becon, Calfhill, Rogers. It is to be noted that all these speak of the rite as "baptism."

‖ See Peuchen, "Disp. circa tempestates," Jena, 1697.

△ See, e. g., the "Conciones Selectæ" of Superintendent Conrad Dieterich (cited by Peuchen, "Disp. circa tempestates").

◊ See Schwimmer, "Physicalische Luftfragen," 1692 (cited by Peuchen, as above). He pictures the whole population of a Thuringian district flocking to the churches on the approach of a storm.

theological current steadily developed through the middle ages, the fundamental idea of the whole being the evident influence of the bells upon the "power of the air"; and it is perhaps worth our while to go back a little and glance over the growth of this deeper current in modern times. Having grown steadily through the middle ages, it appeared in full strength at the Reformation period; and in the sixteenth century Olaus Magnus, Archbishop of Upsala and Primate of Sweden, in his great work on the northern nations, declares it a well-established fact that cities and harvests may be saved from lightning by the ringing of bells and the burning of consecrated incense, accompanied by prayers; and he cautions his readers that the workings of the thunderbolt are rather to be marveled at than inquired into.* Even as late as 1673 the Franciscan professor Lealus, in Italy, in a school-book which was received with great applause in his region, taught unhesitatingly the agency of demons in storms, and the power of bells over them, as well as the portentousness of comets and the movement of the heavens by angels. He dwells especially, too, upon the perfect protection afforded by the waxen *Agnus Dei*. How strong this current was, and how difficult even for philosophical minds to oppose, is shown by the fact that both Descartes† and Francis Bacon speak of it with respect, Bacon admitting the fact, and suggesting very mildly that the bells may accomplish this purpose by the concussion of the air.‡

But no such moderate doctrine sufficed, and the renowned Bishop Binsfeld, of Treves, in his great treatise on the credibility of the confessions of witches, gave an entire chapter to the effect of bells in calming atmospheric disturbances. Basing his general doctrine upon the first chapter of Job and the second chapter of Ephesians, he insisted on the reality of diabolic agency in storms; and then, by theological reasoning, corroborated by the statements extorted in the torture-chamber, he showed the efficacy of bells in putting the hellish legions to flight.* This continued, therefore, an accepted tenet, developed in every nation, and coming to its climax near the end of the seventeenth century. At that period—the period of Isaac Newton—Father Augustine de Angelis, rector of the Clementine College at Rome, published under the highest church authority his lectures upon meteorology. Coming from the center of Catholic Christendom, at so late a period, they are very important as indicating what had been developed under the influence of theology during nearly seventeen hundred years. This learned head of a great college at the heart of Christendom taught that "the surest remedy against thunder is that

* See Olaus Magnus, "De gentibus septentrionalibus" (Rome, 1555), lib. i, c. 12, 13.

† See his "Sylva Sylvarum," cent. ii, p. 103 (cited by Montanus, as above).

‡ See his "Natural History," ii, cent. 2, 127. In his "Historia Ventorum" he again alludes to the belief, and without comment.

* See Binsfeld, "De Confessionibus Malef." (pp. 308-314, of edition of 1623).

which our Holy Mother the Church practices, namely, the ringing of bells when a thunderbolt impends: thence follows a twofold effect, physical and moral—a physical, because the sound variously disturbs and agitates the air, and by agitation disperses the hot exhalations and dispels the thunder; but the moral effect is the more certain, because by the sound the faithful are stirred to pour forth their prayers, by which they win from God the turning away of the thunderbolt." * Here we see in this branch of thought, as in so many others, at the close of the seventeenth century, the dawn of rationalism. Father De Angelis now keeps demoniacal influence in the background. Little, indeed, is said of the efficiency of bells in putting to flight the legions of Satan: the wise professor is evidently preparing for that inevitable compromise which we see in the history of every science when it is clear that it can no longer be suppressed by ecclesiastical fulminations.

But, while this apparently harmless doctrine regarding modes of dealing with the powers of the air was developed, there were evolved another theory and a series of practices sanctioned by the Church, which must forever be considered as among the fearful calamities in human history. Indeed, few errors have ever cost so much shedding of innocent blood over such wide territory and during so many generations. Out of the old doctrine—pagan and Christian—of evil agency in atmospheric phenomena, was evolved the belief that certain men, women, and children had secured infernal aid to produce whirlwinds, frosts, floods, and the like.

As early as the ninth century one great churchman, Agobard, Archbishop of Lyons, struck a heavy blow at this superstition. His work, "Against the Absurd Opinion of the Vulgar touching Hail and Thunder," shows him to have been one of the most devoted apostles of right reason whom human history has known. By argument and ridicule, and at times by a lofty eloquence, he attempted to breast this tide. One passage is of historical significance. He declares: "The wretched world lies now under the tyranny of foolishness; things are believed by Christians of such absurdity as no one ever could aforetime induce the heathen to believe." †

All in vain; the tide of superstition continued to roll on; great theologians developed it and ecclesiastics favored it; until as we near the end of the mediæval period the infallible voice of Rome is heard accepting it, and clinching this belief into the mind of Christianity. For, in 1437, Pope Eugene IV, by virtue of the teaching power conferred on him by the Almighty, and under the divine guarantee

* See De Angelis, "Lectiones Meteorol.," 75.

† For a very interesting statement of Agobard's position and work, with citations from his "Liber contra insulsam vulgi opinionem de grandine et tonitruis," see Poole, "Illustrations of the History of Mediæval Thought," 40, *et seq.* The works of Agobard may be found in vol. civ of Migne's "Patrol. Lat."

against any possible error, issued a bull exhorting the inquisitors of heresy and witchcraft to use greater diligence against the human agents of the Prince of Darkness, and especially against those who have the power to produce bad weather. In 1445 Pope Eugene returned again to the charge, and again issued instructions and commands infallibly committing the Church to the doctrine.* But a greater than Eugene followed and stamped the idea yet more deeply into the mind of the Church. On the 7th of December, 1484, Pope Innocent VIII sent forth his bull "*Summis Desiderantes.*" Of all documents ever issued from Rome, imperial or papal, this has doubtless, first and last, cost the greatest shedding of innocent blood. Yet no document was ever more clearly dictated by conscience. Inspired by the scriptural command, "Thou shalt not suffer a witch to live," Pope Innocent exhorted the clergy of Germany to leave no means untried to detect sorcerers, and especially those who by evil weather destroy vineyards, gardens, meadows, and growing crops.† These precepts were based upon various texts of Scripture, especially upon the famous statement in the book of Job; and, to carry them out, witch-finding inquisitors were authorized by the Pope to scour Europe, especially Germany, and a manual was prepared for their use, the "Witch-Hammer," *Malleus Maleficarum.* In this manual, which was revered for centuries, both in Catholic and Protestant countries, as almost divinely inspired, the doctrine of Satanic agency in atmospheric phenomena was further developed, and various means of detecting and punishing it were dwelt upon.‡

With the application of torture to thousands of women, in accordance with the precepts laid down in this work, it was not difficult to extract masses of proof for this "sacred theory" of meteorology. The poor creatures, writhing on the rack, held in horror by those who had been nearest and dearest to them, anxious only for death to relieve their sufferings, confessed to anything and everything that would satisfy the inquisitors and judges. All that was needed was that the inquisitors should ask leading questions* and suggest satisfactory answers: the prisoners, to shorten the torture, were sure sooner or later to give the answer required, even though they knew that this would

* See Raynaldus, "Annales Eccl.," 1437, 1445.

† The Latin text of the bull may be found in the *Malleus* about to be described, in Binsfeld's "De Confessionibus," cited below, or in Roskoff's "Geschichte des Teufels" (Leipsic, 1869), i, 222–225.

‡ There is, so far as I know, no good analysis, in any English book, of the contents of the "Witch-Hammer"; but such may be found in Roskoff's "Geschichte des Teufels," or in Soldan's "Geschichte der Hexenprozesse." Its first dated edition is that of 1489. It was, happily, never translated into any modern tongue.

* For still extant lists of such questions, see the "Zeitschrift für deutschen Culturgeschichte" for 1858, pp. 522–528, or Diefenbach, "Der Hexenwahn in Deutschland," pp. 15–17. Father Vincent of Berg (in his "Enchiridium") gives a similar list for use by priests in the confession of the accused.

send them to the stake or scaffold. Under the doctrine of "excepted cases," there was no limit to torture for persons accused of heresy or witchcraft; even the safeguards which the old pagan world had imposed upon torture were thus thrown down, and the prisoner *must* confess.

The theological literature of the middle ages was thus enriched with numberless statements regarding modes of Satanic influence on the weather. Pathetic, indeed, are the records; and none more so than the confessions of these poor creatures, chiefly women and children, during hundreds of years, as to their manner of raising hailstorms and tempests. Such confessions, by tens of thousands, are still to be found in the judicial records of Germany, and indeed of all Europe. Typical among these "facts" thus revealed is one on which great stress was laid during ages, and for which the world was first indebted to one of these poor women. Crazed by the agony of torture, she declared that, returning with a demon through the air from the witches' sabbath, she was dropped upon the earth in the confusion which resulted among the hellish legions when they heard the bells sounding the *Ave Maria*. It is sad to note that, after a confession so valuable to sacred science, the poor woman was condemned to the flames. This revelation speedily ripened the belief that, whatever might be going on at the witches' sabbath—no matter how triumphant Satan might be—at the moment of sounding the consecrated bells the Satanic power was paralyzed. This theory once started, proofs came in to support it, during a hundred years, from the torture-chambers in all parts of Europe. Throughout the later middle ages the Dominicans had been the main agents in extorting and promulgating these revelations, but in the centuries following the Reformation the Jesuits devoted themselves with even more keenness and vigor to the same task.* Some curious questions incidentally arose. It was mooted among the orthodox authorities whether the damage done by storms should or should not be assessed upon the property of convicted witches: the theologians inclined decidedly to the affirmative; the jurists, on the whole, to the negative.

But, in spite of these tortures, lightning and tempests continued, and great men arose in the Church throughout Europe in every generation to point out new cruelties for the discovery of "weather-makers," and new methods for bringing their machinations to naught. Here and there, indeed, a thinker endeavored to modify or oppose this view. Early in the sixteenth century Paracelsus called attention to the reverberation of cannon as explaining the rolling of thunder,† but he was confronted by one of the greatest men of his time. Jean Bodin, as superstitious in natural as he was rational in political science, made

* For proofs of this, see not only the histories of witchcraft, but also the "Annuæ litteræ" of the Jesuits themselves, *passim*.

† See the citation from him in Fromond's "Meteorologica," lib. iii, c. 9.

sport of this scientific theory, and declared thunder to be "a flaming exhalation set in motion by evil spirits, and hurled downward with a great crash and a horrible smell of sulphur."* In support of this view, he dwells upon the confessions of tortured witches, upon the acknowledged agency of demons in the will-o'-the wisp, and specially upon the passage in the 104th Psalm, "Who maketh his angels spirits, his ministers a flaming fire."† To resist such powerful arguments by such powerful men was dangerous indeed. In 1513, Pomponatius, professor at Padua, published a volume of "Doubts as to the Fourth Book of Aristotle's Meteorologica,"‡ and also dared to question this power of devils; but he soon found it advisable to explain that, while as a *philosopher* he might doubt, yet as a *Christian* he of course believed everything taught by Mother Church—devils and all—and so escaped the fate of several others who dared to question the agency of witches in atmospheric and other disturbances. Before the end of the sixteenth century, Cornelius Loos, professor in the University of Treves, daring to express similar doubts, was seized by the Inquisition, forced to recant, and banished. Just a century later the Protestant divine, Balthasar Bekker, in Holland, who ventured not only to question the devil's power over the weather, but to deny his bodily existence altogether, was solemnly tried by the synod of his church, and expelled from his pulpit, while his views were condemned as heresy, and overwhelmed with a flood of refutations whose mere catalogue would fill pages; and these cases were but typical of many.

The great upholders of the orthodox view retained full possession of the field. Famous among these was Bishop Binsfeld, of Treves, who, toward the end of the sixteenth century, wrote a book to prove that everything confessed by the witches under torture, especially the raising of storms and the general controlling of the weather, was worthy of belief; and this book became throughout Europe a standard authority, both among Catholics and Protestants.# Even more inflexible was Remigius, criminal judge in Lorraine. On the title-page of his manual‖ he boasts that within fifteen years he had sent nine hundred persons to death for this imaginary crime.

Protestantism fell into the superstition as fully as Catholicism. In

* He adds: "Id certissimam dæmonis præsentiam significat: nam ubicunque dæmones cum hominibus nefaria societatis fide copulantur, fœdissimum semper relinquunt sulphuris odorem, quod sortilegi sæpissime experiuntur et confitentur."

† See Bodin's "Universæ Naturæ Theatrum" (Frankfort, 1597), pp. 208–211.

‡ The first edition of this book, which was the earliest of Pomponatius's writings, is excessively rare; but it was reprinted at Venice just a half-century later. It is in his *De incantationibus*, however, that he speaks especially of devils. As to Pomponatius, see Creighton's "History of the Papacy during the Reformation," and an excellent essay in Franck's "Moralistes et Philosophes."

It bore the title of "Tractatus de confessionibus maleficorum et sagarum." First published at Treves in 1589, it appeared subsequently four times in the original Latin, as well as in two distinct German translations, and in a French one.

‖ "Dæmonolatreia," first printed at Lyons in 1595.

Germany, during the century following the Reformation, the great Saxon jurist, Benedict Carpzov, distinguished himself by his skill in demonstrating the reality of the crime from Scripture, and by his cruelty in detecting and punishing it by torture.

Typical as to the attitude of Scotch and English Protestants, was the theory and practice of King James I, "the crowned Solomon," himself the author of a book on demonology. James had married the Princess of Denmark, and the ship which bore her to the British shores encountered tempests. Skillful use of unlimited torture soon brought the causes to light. A Doctor Fian, while his legs were crushed in the "boots" and wedges driven under his finger-nails, confessed that several hundred witches had gone to sea in a sieve from the port of Leith, and had raised storms and tempests to drive back the king's bride.* Still later, in the second half of the seventeenth century, we see a typical example of the same superstition in England in the case of Meric Casaubon, Doctor of Divinity and an ecclesiastic in high position at Canterbury. He declared fully for the doctrine that witches raise storms, citing the foremost ecclesiastical authorities.†

In America, the great weight of the elder Mather was thrown on the same side.‡ But, in spite of all these great authorities, in every land, and in spite of such summary punishments as those of Loos and Bekker, scientific thought was developed; and, at the end of the seventeenth century, this vast growth of superstition began to wither and droop. Bayle in France, Calef in New England, and Thomasius in Germany, did much to create an intellectual and moral atmosphere fatal to it. Torture being abolished, "weather-makers" no longer confessed; and the fundamental proofs in which the system was rooted were evidently slipping away. Even the great theologian

* The best accounts of James's share in the extortion of these confessions may be found in the collection of "Curious Tracts" published at Edinburgh in 1820. (See also King James's own "Demonologie," and Pitcairn's "Criminal Trials of Scotland," vol. i, part ii, pp. 213–223.)

† See his "Credulity and Incredulity in Things Natural," pp. 66, 67.

‡ Thus, in his sermons (already cited) on "The Voice of God in Stormy Winds" (Boston, 1704), he says: "When there are great Tempests, the Angels oftentimes have an hand therein. . . . Yea, and sometimes, by Divine Permission, Evil Angels have a Hand in such Storms and Tempests as are very hurtful to Men on the Earth." Yet, "for the most part, such Storms are sent by the Providence of God as a Sign of His Displeasure for the Sins of Men," and sometimes "as Prognosticks and terrible Warnings of Great Judgments not far off." And thus from the height of his erudition he rebukes the timid voice of scientific skepticism: "There are some who would be esteemed the Wits of the World, that ridicule those as Superstitious and Weak Persons, which look upon Dreadful Tempests as Prodromous [*sic*] of other Judgments. Nevertheless, the most Learned and Judicious Writers, not only of the Gentiles, but amongst Christians, have Embraced such a Persuasion; their Sentiments therein being Confirmed by the Experience of many Ages." For another curious turn given to this theory, with reference to sanitary science, see Deodat Lawson's famous sermon at Salem, in 1692, on "Christ's Fidelity a Shield against Satan's Malignity" (p. 21 of the second edition).

Fromundus, at the University of Louvain, the oracle of his age, who had demonstrated the futility of the Copernican theory, now tends toward the inevitable attempt at compromise, and declares that devils, though *often*, are not *always*, or even "for the most part," the causes of thunder.* And the learned Jesuit, Caspar Schott, whose "Physica Curiosa" was one of the most popular books of the seventeenth century, ventures only the same mild statement.† But even such a concession by so great champions of orthodoxy did not prevent frantic efforts in various quarters to bring the world back under the old dogma, and, as late as 1743, we find a manual by Father Vincent of Berg,‡ in which the superstition is taught to its fullest extent, issued for the use of priests, under the express sanction of the theological professors of the University of Cologne.

It was hardly out of press, when there came a death-blow to the whole theory. In 1752 Franklin made his experiments with the kite on the banks of the Schuylkill; and, at the moment when he drew the electric spark from the cloud, the whole tremendous fabric of theological meteorology reared by the Fathers, the Popes, the mediæval Doctors, and the long line of great theologians, Catholic and Protestant, collapsed; the "Prince of the power of the air" tumbled from his seat; the great doctrine which had so long afflicted the earth was prostrated forever.

The experiment of Franklin was repeated in various parts of Europe, but, at first, the Church seemed careful to take no notice of it. The old church formulas against the powers of the air were still used, but the theological theory, especially in the Protestant Church, began to grow milder. Four years after Franklin's discovery Pastor Karl Koken, member of the Consistory and official preacher to the City Council of Hildesheim, was moved by a great hailstorm to preach and publish a sermon on "The Revelation of God in Weather."# Of "the prince of the power of the air" he says nothing—the whole theory of diabolical agency is thrown overboard altogether; his whole attempt is to save the older and more harmless theory, that the storm is the voice of God. He insists that, since Christ told Nicodemus that men "know not whence the wind cometh," it can not be of mere natural origin, but is sent directly by God himself, as David intimates in the Psalm, "out of His secret places." As to the hailstorm, he lays great stress upon the plague of hail sent by the Almighty upon Egypt, and

* See Fromundus's "Meteorologica" (London, 1656) lib. iii, c. 9, and lib. ii, c. 3.

† See Schott's "Physica Curiosa" (edition of Würzburg, 1667), p. 1249.

‡ His "Enchiridium quadripartitum" (Cologne, 1743). Besides benedictions and exorcisms for all emergencies, it contains full directions for the manufacture of the *Agnus Dei*, and of another sacred panacea called "Heiligthum," not less effective against evil powers, gives formulæ to be worn for protection against the devil, suggests a list of signs by which diabolical possession may be infallibly recognized, and prescribes the questions to be asked by priests in the examination of witches.

"Die Offenbarung Gottes in Wetter" (Hildesheim, 1756).

clinches all by insisting that God showed at Mount Sinai his purpose to startle the body before impressing the conscience.

While the theory of diabolical agency in storms was thus drooping and dying, very shrewd efforts were made at compromise, such as we always see in the history of every science when its victory is fully in sight. The first of these attempts we have already noted in the effort to explain the efficacy of bells in storms by their simple use in stirring the faithful to prayer, and in the concession made by sundry theologians, and even by the great Lord Bacon himself, that church-bells might, under the sanction of Providence, disperse storms by agitating the air. This gained ground somewhat, though it was resisted by one eminent church authority, who answered shrewdly that, in that case, cannon would be even more pious instruments.* Still another argument used in trying to save this part of the theological theory was that the bells were consecrated instruments for this purpose, "like the horns at whose blowing the walls of Jericho fell."

But these compromises were of little avail. In 1766 Father Sterzinger attacked the very groundwork of the whole diabolic theory. He was, of course, bitterly assailed, insulted, and hated; but the Church thought it best not to condemn him. More and more, the "Prince of the power of the air" retreated before the lightning-rod of Franklin. The older Church, while clinging to the old theory theoretically, was finally obliged to confess the supremacy of Franklin's theory practically; for his lightning-rod did what exorcisms, and holy water, and processions, and the *Agnus Dei*, and the ringing of church-bells, and the rack, and the burning of witches, had failed to do. This was clearly seen, even by the poorest peasants in Eastern France, when they observed that the grand spire of Strasburg Cathedral, which neither the sacredness of the place, nor the bells within it, nor the holy water and relics beneath it, could protect from frequent injuries by lightning, was once and for all protected by Franklin's rod. Then came into the minds of multitudes the answer to the question which had exercised for ages the leading theological minds of Europe, namely, "Why should the Almighty strike his own consecrated temples, or suffer Satan to strike them?"

Yet even this practical solution of the great question was not received without opposition. The first lightning-conductor upon a church in England was not put up until 1762, ten years after Franklin's discovery. The spire of Saint Bride's Church in London was greatly injured by lightning in 1750, and in 1764 a storm so wrecked its masonry that it had to be mainly rebuilt; yet for years after this the authorities refused to attach a lightning-rod!† The Protestant Cathedral of Saint Paul's in London was not protected until sixteen years after Franklin's discovery, and the tower of the great Protestant church at Hamburg

* See Gretser's "De Benedictionibus," lib. ii, c. 46.

† See Priestley, "History of Electricity," p. 407.

not until a year later still. As late as 1783 it was declared in Germany, on excellent authority, that within a space of thirty-three years nearly four hundred towers had been damaged, and one hundred and twenty bell-ringers killed.

In Roman Catholic countries a similar prejudice was shown, and its cost at times was heavy. In Austria the church of Rosenberg, in the mountains of Carinthia, was struck so frequently, and with such loss of life, that the peasants feared at last to attend service. Three times was the spire rebuilt, and it was not until 1778—twenty-six years after Franklin's discovery—that the authorities permitted a rod to be attached. Then all trouble ceased.

Typical in Italy was the tower of Saint Mark's at Venice. In spite of the angel at its summit and the bells consecrated to ward off the powers of the air, and the relics in the cathedral hard by, and the processions in the adjacent piazza, the tower was frequently injured and even ruined by lightning. In 1388 it was badly shattered; in 1417, and again in 1489, the wooden spire surmounting it was utterly consumed; it was again greatly injured in 1548, 1565, 1653, and in 1745 was struck so powerfully that the whole tower, which had been rebuilt of stone and brick, was shattered in thirty-seven places. Although the invention of Franklin had been introduced into Italy by the physicist Beccaria, the tower of Saint Mark's still went unprotected, and was again badly struck in 1761 and 1762; and not until 1766—fourteen years after Franklin's discovery—was a lightning-rod placed upon it: and it has never been struck since.

So, too, though the beautiful tower of the Cathedral of Siena, protected by all possible theological means, had been struck again and again, much opposition was shown to placing upon it what was generally known as "the heretical rod"; but the tower was at last protected by Franklin's invention, and in 1777, though a very heavy bolt passed down the rod, the church received not the slightest injury. This served to reconcile theology and science, so far as that city was concerned; but the case which did most to convert the Italian theologians to the scientific view was that of the church of Saint-Nazaire at Brescia. The Republic of Venice had stored in the vaults of this church over two hundred thousand pounds of powder. In 1767—seventeen years after Franklin's discovery—no rod having been placed upon it, it was struck by lightning, the powder in the vaults was exploded, one sixth of the entire city destroyed, and over three thousand lives lost.*

Such examples as these, in all parts of Europe, had their effect. The formulas for conjuring off storms, and for consecrating bells to ward off lightning and tempests, and for putting to flight the powers of the air, were still allowed to stand in the liturgies; but the lightning-rod, the barometer, and the thermometer, carried the day.

* See article on "Lightning" in the "Edinburgh Review" for October, 1844.

A noble line of investigators succeeding Franklin completed his victory. The traveler in remote districts of Europe still hears the church-bells ringing during tempests; the Polish or Italian peasant is still persuaded to pay fees for sounding bells to keep off hailstorms; but the universal tendency favors more and more the use of the lightning-rod, and of the insurance-offices where men can be relieved of the ruinous results of meteorological disturbances in accordance with the scientific laws of average, based upon the ascertained recurrence of storms. So, too, though many a poor seaman trusts to his charm that has been bathed in holy water, or that has touched some relic, the tendency among mariners is to value more and more those warnings which are sent far and wide each day over the earth and under the sea by the electric wires in accordance with laws ascertained by observation.

Yet, even in our own time, attempts to revive the old theological doctrine of meteorology have not been wanting. Two of these, one in a Roman Catholic and another in a Protestant country, will serve as types of many, to show how completely scientific truth has saturated and permeated minds supposed to be entirely surrendered to the theological view.

The Island of Saint Honorat, just off the southern coast of France, is deservedly one of the places most venerated in Christendom. The monastery of Lérins, founded there in the fourth century, became a mother of similar institutions in Western Europe, and a center of religious teaching for the Christian world. In its atmosphere, legends and myths grew in beauty and luxuriance. Here, as the chroniclers tell us, at the touch of Saint Honorat, burst forth a stream of living water, which a recent historian of the monastery declares a greater miracle than that of Moses; here he destroyed, with a touch of his staff, the reptiles which infested the island, and then forced the sea to wash away their foul remains. Here, to please his sister, Sainte-Marguerite, a cherry-tree burst into full bloom every month; here he threw his cloak upon the waters and it became a raft, which bore him safely to visit the neighboring island; here, Saint Patrick received from Saint Just the staff with which he imitated Saint Honorat by driving all reptiles from Ireland.

Pillaged by Saracens and pirates, the island was made all the more precious by the blood of Christian martyrs. Popes and kings made pilgrimages to it; saints, confessors, and bishops went forth from it into all Europe; in one of its cells, Saint Vincent of Lérins wrote that famous definition of pure religion* which, for nearly fifteen hundred years, has virtually superseded that of Saint James. Naturally, the monastery became most illustrious, and its seat "the Mediterranean Isle of Saints."

* That "religion is that which is received always, everywhere, and by all" (*semper, ubique, ab omnibus*).

But, toward the close of the last century, its inmates having become slothful and corrupt, it was dismantled, all save a small portion torn down, and the island became the property, first of impiety, embodied in a French actress, and finally of heresy, embodied in an English clergyman.

Bought back for the Church by the Bishop of Fréjus in 1869, there was little revival of life for twelve years. Then came the reaction, religious and political, after the humiliation of France and the Vatican by Germany; and of this reaction the monastery of Saint Honorat was made one of the most striking outward and visible signs. Pius IX interested himself directly in it, called into it a body of Cistercian monks, and it became the chief seat of their order in France. To restore its sacredness the strict system of La Trappe was established—labor, silence, meditation on death. The word thus given from Rome was seconded in France by cardinals, archbishops, and all churchmen especially anxious for promotion in this world or salvation in the next. Worn-out dukes and duchesses of the Faubourg Saint-Germain united in this enterprise of pious reaction with the frivolous youngsters, the *petits crevés*, who haunt the purlieus of Notre Dame de Lorette. The great church of the monastery was handsomely rebuilt and a multitude of altars erected; and beautiful frescoes and stained windows came from the leaders of the recation. The whole effect was, perhaps, somewhat too theatrical and thin, but it showed none the less earnestness in making the old "Isle of Saints" a protest against the hated modern world.

As if to bid defiance still further to modern liberalism, great store of relics was sent in—among these, pieces of the true cross, of the white and purple robes, of the crown of thorns, sponge, lance, and winding-sheet of Christ—the hair, robe, veil, and girdle of the Blessed Virgin—relics of Saint John the Baptist, Saint Joseph, Saint Mary Magdalene, Saint Paul, Saint Barnabas, the four Evangelists, and a multitude of other saints; so many that the bare mention of these treasures requires twenty-four distinct heads in the official catalogue recently published at the monastery. Besides all this—what was considered even more powerful in warding off harm from the revived monastery—the bodies of Christian martyrs were brought from the Roman catacombs and laid beneath the altars.*

All was thus conformed to the mediæval view; nothing was to be left which could remind one of the nineteenth century; the "ages of faith" were to be restored in their simplicity. Pope Leo XIII commended to the brethren the writings of Saint Thomas Aquinas, as their one great object of study; and works published at the monastery dwelt upon the miracles of Saint Honorat as the most precious refutation of modern science.

* See the "Guide des Visiteurs à Lérins," published at the monastery in 1880, p. 204; also the "Histoire de Lérins," mentioned below.

High in the cupola, above the altars and relics, were placed the bells. Sent by pious donors, they were solemnly baptized and consecrated in 1871, four bishops officiating, a multitude of the faithful being present from all parts of Europe, and the sponsors of the great tenor bell being the Bourbon claimant to the ducal throne of Parma and his duchess. The good bishop who baptized the bells consecrated them with a formula announcing their efficacy in driving away the "prince of the power of the air," and the lightning and tempests he provokes.

And then, above all, at the summit of the central spire, high above relics, altars, and bells, was placed—*a lightning-rod!**

The account of the monastery, published under the direction of the present worthy abbot, more than hints at the saving, by its bells, of a ship which was wrecked a few years since on that coast; and yet, to protect the bells and church and monks and relics from the very foe whom, in the mediæval faith, all these were thought most powerful to drive away, recourse was had to the scientific discovery of that "arch-infidel," Benjamin Franklin!

Perhaps the most striking recent example in Protestant lands of this change from the old to the new, occurred not long since in one of the great Pacific dependencies of the British crown. At a time of severe drought, an appeal was made to the bishop, Dr. Moorhouse, to order public prayers for rain. The bishop refused, advising the petitioners for the future to take better care of their water-supply, virtually telling them, "Heaven helps those who help themselves." But most noteworthy in this matter was it that the English Government, not long after, scanning the horizon to find some man to take up the good work laid down by the lamented Bishop Fraser, of Manchester, chose Dr. Moorhouse; and his utterance upon meteorology, which a few generations since would have been regarded by the whole Church as blasphemy, was universally alluded to as an example of strong good sense, proving him especially fit for one of the most important bishoprics in England.

Throughout Christendom, the prevalence of the conviction that meteorology is obedient to laws, is more and more evident. In cities especially, where men are accustomed each day to see posted in public places charts which show the storms moving over various parts of the country, and to read in the morning papers scientific prophecies as to the weather, the old view can hardly be very influential.

* See "Guide," as above, p. 84. "Les Isles de Lérins," by the Abbé Alliez (Paris, 1860), and the "Histoire de Lérins," by the same author, are the authorities for the general history of the abbey, and are especially strong in presenting the miracles of Saint Honorat, etc. The "Cartulaire" of the monastery, recently published, is also valuable. But these do not cover the recent revival, for an account of which recourse must be had to the very interesting and *naïve* "Guide" already cited.

Significant of this was the feeling of the American people during the fearful droughts a few years since in the States west of the Missouri. No days were appointed for fasting and prayer to bring rain —there was no attribution of the calamity to the wrath of God or the malice of Satan; but much was said regarding the folly of our people in allowing the upper regions of their vast rivers to be denuded of forests, thus subjecting the States below to alternations of drought and deluge. Partly as a result of this, a beginning has been made of teaching forest-culture in many schools, tree-planting societies have been formed, and "Arbor-day" is recognized in several of the States. A true and noble theology can hardly fail to recognize in the love of Nature and care for our fellow-men thus promoted, something far better, both from a religious and a moral point of view, than any efforts to propitiate the Divine anger by flattery, or to avert Satanic malice by fetichism.

THE FALLS OF THE MISSISSIPPI.

By JOHN ARNOLD KEYES.

THE Mississippi River and its tributaries, forming as they do one of the most important river systems on the globe, and draining one of the most richly-furnished continental areas, present, moreover, many interesting geological studies, and open up fields of curious inquiry to the investigator. The old discussions as to the possibility or impossibility of things has, for the most part, passed out of existence in this department of science. No one now denies the general principles of geology as at present taught; therefore new regions of investigation are to be approached on the firm foundation of the old, and difficult matters settled in conformity with established principles. That there is no new thing under the sun is a saying well worn, but in one sense correct, yet the same thing recognized as a fact in one situation may under other circumstances seem a fallacy. The Falls of Niagara are familiar to all, and came to exist through causes natural and easy of explanation, inasmuch as the whole secret lies in the character of the formations over which the river flows, viz., a crust made up of from sixty to one hundred feet of comparatively hard limestone lying in a nearly horizontal position, beneath which is a deep deposit of shales and sandstones. Whenever the river in wearing its channel back reached the point where this arrangement of rocks began, the hard limestone would naturally resist the erosive action of the waters, while the underlying shales and sandstones, offering less resistance, would be rapidly cut away, until a vertical fall such as is now seen would be the result, with a constant recession going on, leaving below the broad cañon, walled on either hand by bluffs, the crests of which are preserved by the limestone crowning them.

These few reflections as to the falls and gorge of Niagara, fully demonstrated by forces now in active operation, we shall apply to the Mississippi. Here also a mighty water-way has been cut out by erosion, a fact which is universally conceded, but no definite explanation of the process has heretofore, so far as we have been able to learn, been advanced. It remained for a geology-reading inventor by the name of Robert Bates to suggest a theory which, illuminated with what little investigation we have been able to give it, promises to offer a solution of the question, or to assist in its solution. The theory briefly is, that the erosion was accomplished by means of a mighty cataract which began far down the river near its original mouth, and by gradual retrocession dug out the valley-like gorge which is so marked a feature in the upper part of its course, and left the high bluff walls on either hand, at the same time depositing heavy beds of sand at the bottom of the cañon, the product of the erosion above, and that St. Anthony Falls are the ever decreasing and receding remnants of the once most stupendous cataract the world ever saw, having a perpendicular descent of perhaps six hundred feet.

Stretching over almost the entire Mississippi Valley immediately overlying the Azoic rocks lie the old and extensive beds of the Potsdam sandstone, a formation of great thickness composed of shales and friable sandstones.

From the Wisconsin River to the Falls of St. Anthony the formations through which the Mississippi has cut its way are—first, the St. Lawrence, or, as Owen has termed it, lower magnesian limestone, very analogous to the Niagara formation in density and durability.

This stratum is from one hundred and fifty to two hundred and twenty-five feet in thickness, and lies in a nearly horizontal position, dipping somewhat to the west, but not to any great extent between the Wisconsin River and St. Anthony Falls. Second, underlying this and forming a part of the Potsdam group is the St. Croix sandstone, with perhaps other sand-rock and shales local in extent. A section of the bluff in Houston County, Minnesota, gives the St. Lawrence crowning it a thickness of nearly two hundred feet, with three hundred and twenty feet of sand-rock and shale beneath.

Another measurement of a bluff in the town of Richmond, Winona County, indicates a little over one hundred and ten feet of limestone overlying four hundred feet of St. Croix sandstone. Other measurements have been made in different localities, but without doubt these already given indicate the general positions and relative thickness of the different strata. The conditions, it will here be observed, are similar to those existing at Niagara, viz., a hard limestone superimposing a soft sandstone and shale deposit.

These bluff walls rise on either hand to a height of from three hundred to five hundred and fifty feet above the water-level of the river, and have been laterally furrowed and eroded by streams flowing from

the adjacent country, and in a much greater degree by glacial action, as it is a well-established fact that the river had cut its way (except for a short distance below St. Anthony) prior to the glacial epoch. On account of this lateral furrowing the bluff walls present a broken and serrated appearance, but this, when rightly considered, does not in the least militate against the correctness of the cataract theory. The valley gorge, which is from two to six miles, is at present somewhat wider at the top where the cliffs appear, and where wind and frost have been free to act, than the water originally cut it, and the *débris* falling below has formed a talus which, increased and modified by glacial action, has to a considerable extent effaced the wall-like appearance which is such a marked feature of the comparatively freshly-cut cañon of Niagara.

Another fact which has hitherto received no satisfactory explanation is the deep accumulation of sand in the valley-bottom. There are no data sufficient to determine the depth of this deposit, but as the great river nowhere flows upon a rock-bed, but everywhere, except in its extreme northern section, has a sand bottom; and, as cities and villages are built within the bluffs on the compact accumulations at the sides of the present channel, we conclude that it must have a depth of several hundred feet.

If the gorge had been chiseled out by a process of gradual wear (which would have been the case if the strata had been of uniform resisting power), then the river should flow upon a rock-bed, and not upon sand, for the latter would, as it now does, protect the underlying strata from all wear. Upon the cataract hypothesis this peculiar condition can be met with an easy and satisfactory explanation. The descent of the Mississippi is very gradual. Directly at the base of the falls, wherever they may have originated, the sand-rock would be cut down to a depth determined by the comparative hardness of the rocks and the volume of water. For a short distance below the descent the rock would be swept clean of sand and *débris*, except, perhaps, the large limestone chunks fallen from above, but as the stream came to flow more evenly below the falls, sand from the erosion above would be deposited at the bottom. Two other existing conditions would assist in the deposit: first, the very slight fall of the river; and, second, the detached masses of limestone broken from the crest of the falls would help to collect and retain the sediment, and thus the accumulation would begin. All these facts, taken in connection with the further fact that no bluffs appear above St. Anthony Falls, while they are continuous below, except where broken by the lateral erosion, have a tendency to establish the theory advanced. Just how far to the south the requisite conditions of stratification exist, we have not as yet ascertained, but they probably exist wherever the limestone-capped bluffs bound the river. If the limestone formation is wanting at any place, there rapids would have taken the place of falls,

and so continued until the limestone again appeared in its natural position.

There are no rock-bluffs below the confluence of the Ohio with the Mississippi, but about thirty miles above that point they abruptly rise on both sides of the river at what is called the Grand Chain, a high rock ridge traversing the region from east to west, and which lies at a considerable height above the sea-level. There, in all probability, the river had its original outlet, and there, without doubt, the cataract process began, although the character of the stratification is unknown to us. At the time the erosion was in progress, there must have been several times the present volume of water flowing in the river, spreading out wider than the bluff, even, as an occasional terrace shows. The same perpendicular rock-walls and sand-bottom characterize the Wisconsin River for a distance of eighty miles from its junction with the Mississippi; the position and character of the stratification being much the same, indicating that the same agency was active in the erosion of both channels.

St. Anthony Falls have been studied by Professor Winchell, and he has arrived at the conclusion from various data that the falls have worked their way back from a point near Fort Snelling to where they now are, a distance of about eight miles, since the glacial period, and he estimates that it has taken about five thousand years to accomplish the work, which estimate, taken as a basis of calculation, and allowing a margin of at least one third, gives us the time necessary to cut out the entire channel at, say, four hundred thousand years; and this, if, as we maintain, the cataract process wrought the gorge not only from Fort Snelling northward, but from far down the river, at or near the ancient outlet, is without doubt a conservative estimate of the time actually required.

We have thus briefly outlined the new theory of the Mississippi erosion, and this is written with the expectation that the barbed arrows of scientific criticism will be aimed toward it; but, if so, it will aid in the solution of a question hitherto little studied. Many things point toward the theory here advanced as being at least quite possible, and even probable. Its final solution will, however, necessitate painstaking investigation, with the attention directed to that especial object.

MADAME CLÉMENCE ROYER, writing in the "Revue d'Anthropologie," does not doubt that, under a proper system of training, apes might be made good workers. They lack perseverance, indeed, but in general intelligence they are superior to most other domestic animals. They would, however, have to be fed great quantities of fruit, bread, and eggs; the process of educating them would be costly; and for many generations they would be injuriously affected by northern climates. Madame Royer suggests that, if the experiment be made, it be first in tropical climates, where apes might be taught to labor in connection with the cultivation of coffee, cocoa, and cotton.

ASTRONOMY WITH AN OPERA-GLASS.

THE MOON AND THE SUN.

By GARRETT P. SERVISS.

"IT is a most beautiful and delightful sight," exclaims Galileo, in describing the discoveries he had made with his telescope, "to behold the body of the moon, which is distant from us nearly sixty semi-diameters of the earth, as near as if it was at a distance of only two of the same measures. . . . And, consequently, any one may know with the certainty that is due to the use of our senses that the moon assuredly does not possess a smooth and polished surface, but one rough and uneven, and, just like the face of the earth itself, is everywhere full of vast protuberances, deep chasms, and sinuosities."

There was, perhaps, nothing in the long series of discoveries with which Galileo astonished the world after he had constructed his telescope, which, as he expresses it, "was devised by me through God's grace first enlightening my mind," that had a greater charm for him than his lunar observations. Certainly there was nothing which he has described with greater enthusiasm and eloquence. And this could hardly have been otherwise, for the moon was the first celestial object to which Galileo turned his telescope, and then for the first time human eyes may be said to have actually looked into another world than the earth, though his discoveries and those of his successors have not realized all the poetic fancies about the moon contained in the verses that are ascribed to Orpheus :

> "And he another wandering world has made
> Which gods Selene name, and men the moon.
> It mountains, cities has, and temples grand."

Yet Galileo's observations at once upset the theory, for which Apollonius was responsible, and which seems to have been widely prevalent up to his time, that the moon was a smooth body, polished like a mirror, and presenting in its light and dark spots reflections of the continents and oceans of the earth. He also demonstrated that its surface was covered with plains and mountains, but the "cities and temples" of the moon have remained to our time only within the ken of romance.

Galileo's telescope, as I have before remarked, was, in the principle of its construction, simply an opera-glass of one tube. He succeeded in making a glass of this kind that magnified thirty diameters, a very much higher power than is given to the opera- and field-glasses of today. Yet he had to contend with the disadvantages of single lenses, achromatic combinations of glass for optical purposes not being con-

trived until nearly a hundred years after his death, and so his telescope did not possess quite as decided a superiority over a modern field-glass as the difference in magnifying power would imply. In fact, if the reader will view the moon with a first-rate field-glass, he will perceive that the true nature of the surface of the lunar globe can be readily discerned with such an instrument. Even a small opera-glass will reveal much to the attentive observer of the moon; but for these observations the reader should, if possible, make use of a field-glass, and the higher its power the better. The illustrations accompanying this article were made by the author with the aid of a glass magnifying six diameters.

Of course, the first thing the observer will wish to see will be the mountains of the moon, for everybody has heard of them, and the most sluggish imagination is stirred by the thought that one can look off into the sky and behold "the eternal hills" of another planet as solid and substantial as our own. But the chances are that, if left to their own guidance, ninety-nine persons out of a hundred would choose exactly the wrong time to see these mountains. At any rate, that is my experience with people who have come to look at the moon through my telescope. Unless warned beforehand, they invariably wait until full moon, when the flood of sunshine poured perpendicularly upon the face of our satellite conceals its rugged features as effectually as if a veil had been drawn over them. Begin your observations with the appearance of the narrowest crescent of the new moon, and follow it as it gradually fills, and then you will see how beautifully the advancing line of lunar sunrise reveals the mountains, over whose slopes and peaks it is climbing, by its ragged and sinuous outline. The observer must keep in mind the fact that he is looking straight down upon the tops of the lunar mountains. It is like a view from a balloon, only at a vastly greater height than any balloon has ever attained. Even with a powerful telescope the observer sees the moon at an apparent distance of several hundred miles, while with a field-glass, magnifying six diameters, the moon appears as if forty thousand miles off. The apparent distance with Galileo's telescope was eight thousand miles. Recollect how when seen from a great height the rugosities of the earth's surface flatten out and disappear, and then try to imagine how the highest mountains on the earth would look if you were suspended forty thousand miles above them, and you will, perhaps, rather wonder at the fact that the moon's mountains can be seen at all.

It is the contrast of lights and shadows that not only reveals them to us, but enables us to measure their height. On the moon shadows are very much darker than upon the earth, because of the extreme rarity of the moon's atmosphere, if indeed it has any atmosphere at all. By stepping around the corner of a rock there, one might pass abruptly from dazzling noonday into the blackness of midnight. The surface of the moon is extraordinarily rough and uneven. It possesses

broad plains, which are probably the bottoms of ancient seas that have now dried up, but these cover only about two fifths of the surface visible to us, and most of the remaining three fifths are exceedingly rugged and mountainous. Many of the mountains of the moon are, foot for foot, as lofty as the highest mountains on the earth, while all of them, in proportion to the size of the moon's globe, are much larger than the earth's mountains. It is obvious, then, that the sunshine as it creeps over these Alpine landscapes in the moon, casting the black shadows of the peaks and craters many miles across the plains, and capping the summits of lofty mountains with light, while the lower regions far around them are yet buried in night, must clearly reveal the character of the lunar surface. Mountains that can not be seen at all when the light falls perpendicularly upon them, or, at the most, appear then merely as shining points, picture themselves by their shadows in startling silhouettes when illuminated laterally by the rising sun.

But at full moon, while the mountains hide themselves in light, the old sea-beds are seen spread out among the shining table-lands with great distinctness. Even the naked eye readily detects these as ill-defined, dark patches upon the face of the moon, and to their presence are due the popular notions that have prevailed in all quarters of the world about the "Man in the Moon," the "Woman in the Moon," "Jacob in the Moon," the "Hare in the Moon," the "Toad in the Moon," and so on. But, however clearly one may imagine that he discerns a man in the moon while recalling the nursery rhymes about him, an opera-glass instantly puts the specter to flight, and shows the round lunar disk diversified and shaded like a map.

A feature of the full moon's surface that instantly attracts attention is the remarkable brightness of the southern part of the disk, and the brilliant streaks radiating from a bright point near the lower edge. The same simile almost invariably comes to the lips of every person who sees this phenomenon for the first time—"It looks like a peeled orange." The bright point, which is the great crater-mountain Tycho, looks exactly like the pip of the orange, and the light streaks radiating from it in all directions bear an equally striking resemblance to the streaks that one sees upon an orange after the outer rind has been removed. I shall have something more to say about these curious streaks farther on; in the mean time, let us glance at our first illustration, which is a small sketch-map of the moon.

The so-called seas are marked on the map, for the purpose of reference, by the letters which they ordinarily bear in lunar maps. The numerals indicate craters, or ring-plains, and mountain-ranges. The following key-list will enable the reader to identify all the objects that are lettered or numbered upon the map. I have given English translations of the Latin names which the old astronomers bestowed upon the seas:

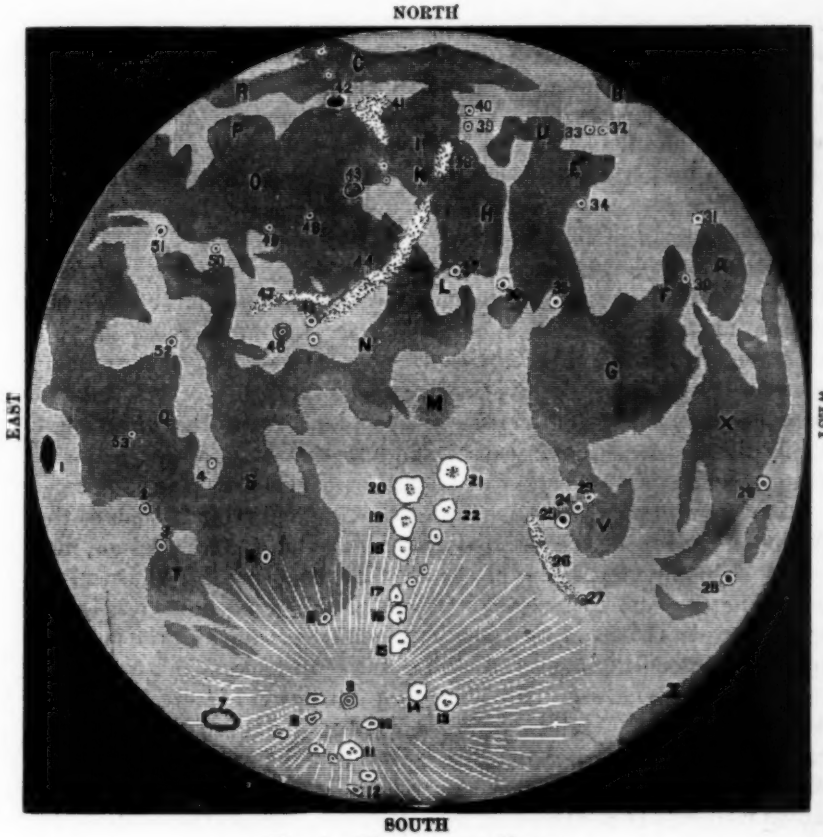


FIG. 1.—MAP OF THE MOON.

Seas, Gulfs, and Marshes.

A. The Crisian Sea.
B. Humboldt Sea.
C. The Sea of Cold.
D. The Lake of Death.
E. The Lake of Dreams.
F. The Marsh of Sleep.
G. The Sea of Tranquillity.
H. The Sea of Serenity.
I. The Marsh of Mists.
K. The Marsh of Putrefaction.
L. The Sea of Vapors.
M. The Central Gulf.
N. The Gulf of Heats.
O. The Sea of Showers.
P. The Bay of Rainbows.
Q. The Ocean of Storms.
R. The Bay of Dew.
S. The Sea of Clouds.
T. The Sea of Humors.
V. The Sea of Nectar.
X. The Sea of Fertility.
Z. The South Sea.

Mountains and Crater Rings.

1. Grimaldi.
2. Letronne.
3. Gassendi.
4. Euclides.
5. Bullialdus.
6. Pitatus.
7. Schickhard.
8. Longomontanus.
9. Tycho.
10. Maginus.
11. Clavius.
12. Newton.
13. Maurolycus.
14. Stöfler.
15. Walter.
16. Regiomontanus.
17. Purbach.
18. Arzachel.
19. Alphonsus.
20. Ptolemæus.
21. Hipparchus.
22. Albategnius.
23. Theophilus.
24. Cyrillus.
25. Catharina.
26. The Altai Mountains.
27. Piccolomini.
28. Petavius.
29. Langrenus.
30. Proclus.
31. Cleomedes.
32. Atlas.
33. Hercules.
34. Posidonius.
35. Plinius.
36. Menelaus.
37. Manilius.
38. The Caucasus Mountains.
39. Eudoxus.
40. Aristotle.
41. The Alps.
42. Plato.
43. Archimedes.
44. The Apennines.
45. Eratosthenes.
46. Copernicus.
47. The Carpathian Mts.
48. Timocharis.
49. Lambert.
50. Euler.
51. Aristarchus.
52. Kepler.
53. Flamsteed.

The early selenographers certainly must have been men of vivid imagination, and the romantic names they gave to the lunar landscapes, and particularly to the "seas," add a charm of their own to the study of the moon. Who would not wish to see the "Bay of

Rainbows," or the "Lake of Dreams," or the "Sea of Tranquillity," if for no other reason than a curiosity to know what could have induced men to give to these regions in the moon such captivating names? Or who would not desire to visit them if he could? though no doubt we should find them, like the "Delectable Mountains" in the "Pilgrim's Progress," most charming when seen from afar.

The limited scale of our map, of course, rendered it impossible to represent upon it more than a comparatively small number of the lunar mountains that have received names. In selecting those to be put in the map, I have endeavored to choose such as, on account of their size, their situation, or some striking peculiarity, would be most likely to attract the attention of a novice. The observer must not expect to see them all at once, however. The lunar features change their appearance to a surprising extent, in accordance with the direction of their illumination. Some great mountain-masses and ring-plains, or craters, which present scenes of magnificence when the sun is rising or setting upon them, disappear under a perpendicular light, such as they receive at full moon. The great crater-plain, known as Maginus, numbered 10 in our map, is one of these. The broken mountain-wall surrounding this vast depressed plain rises in some places to a height of over fourteen thousand feet above the valley within, and the spectacle of sunrise upon Maginus, seen with a powerful telescope, is a most impressive sight, and even with a field-glass it is very interesting. Yet, a few days later, Maginus vanishes, as if it had been swallowed up, and as Beer and Mädler have expressed it, "the full moon knows no Maginus." The still grander formation of mountain, plain, and crater, called Clavius (11 in the map), disappears almost as completely as Maginus at full moon, yet, under the proper illumination, it presents a splendid pageant of light and shadow.

On the other hand, some of the lunar mountains shine vividly at full moon, and can be well seen then, though, of course, only as light spots, since at that time they cast no shadows. Menelaus (36 in the map), Aristarchus (51), Proclus (30), Copernicus (46), and Kepler (52), are among these shining mountains. Aristarchus is the most celebrated of them all, being the brightest point on the moon. It can even be seen glimmering on the dark side of the moon—that is to say, when no light reaches it except that which is reflected from the earth. With a large telescope, Aristarchus is so dazzlingly bright under a high sun, that the eye is partly blinded in gazing at it. It consists of a mountain-ring surrounding a circular valley, about twenty-eight miles in diameter. The flanks of these mountains, especially on their inner slopes, and the floor of the valley within, are very bright, while a peak in the center of the valley, about as high as Storm King Mountain on the Hudson, shines with piercing brilliancy. Sir William Herschel mistook it for a volcano in action. It certainly is not an active volcano, but just what makes it so dazzling no one knows. The ma-

terial of which this mountain is formed, would seem to possess a higher reflective power than that of any other portion of the moon's surface. One is irresistibly reminded of the crystallized mountains described in the celebrated "Moon Hoax" of Richard Adams Locke. With an opera-glass, you can readily recognize Aristarchus as a bright point at full moon. With a field-glass it is better seen, and some of the short, light rays surrounding it are perceived, while, when the sun is rising upon it, about four days after first quarter, its crateriform shape can be detected with such a glass.

FIG. 2.—SUNRISE ON THE SEA OF SERENITY, AND THEOPHILUS AND OTHER CRATERS.

The visibility of Aristarchus on the dark side of the moon leads us to a brief consideration of the illumination by the earth of that portion of the moon's surface which is not touched directly by sunlight at new and old moon. This phenomenon is shown in our second illustration. Not only can the outlines of the dark part of the moon be seen under such circumstances, but even the distinction in color between the dusky "seas" and the more brilliant table-lands and mountain-regions can be perceived, and with powerful telescopes many minor features come into sight. A little consideration must convince any one, as it convinced Galileo more than two hundred and seventy-five years ago, that the light reflected from the earth upon the moon is sufficient to produce this faint illumination of the lunar landscapes. We have only to recall the splendors of a night that is lighted by a full moon, and then to recollect that at new or old moon the earth is "full" as seen from our satellite, and that a full earth must give some fourteen times as much light as a full moon, in order to realize the brilliancy of an earth-lit night upon the moon. As the moon waxes to us, the earth wanes to the moon, and *vice versa*, and so the

phenomenon of earth-shine on the lunar surface must be looked for before the first quarter and after the last quarter of the moon.

The reader will find it an attractive occupation to identify, by means of the map, the various "seas," "lakes," and "marshes," for not only are they interesting on account of the singularity of their names, but they present many remarkable differences of appearance, which may be perceived with the instrument he is supposed to be using. The oval form of the Crisian Sea (A), which is the first of the "seas" to come into sight at new moon, makes it a very striking object. With good telescopes, and under favorable illumination, a decidedly green tint is perceived in the Crisian Sea. It measures about two hundred and eighty by three hundred and fifty-five miles in extent, and is, perhaps, the deepest of all the old sea-beds visible on the moon. It is surrounded by mountains, which can be readily seen when the sun strikes athwart them a few days after new or full moon. On the southwestern border a stupendous mountain-promontory, called Cape Agarum, projects into the Crisian Sea fifty or sixty miles, the highest part rising precipitously eleven thousand feet above the floor of the sea. I have seen Cape Agarum very clearly defined with a field-glass. Near the eastern border is the crater-mountain Proclus, which I have already mentioned as possessing great brilliancy under a high sun, being in this respect second only to Aristarchus.

From the foot of Proclus spreads away the somewhat triangular region called the Marsh of Sleep (F). The term "golden-brown," which has been applied to it, perhaps describes its hue well enough. With a telescope it is a most interesting region, but with less powerful instruments one must be content with recognizing its outline and color.

The broad, dark-gray expanse of the Sea of Tranquillity (G) will be readily recognized by the observer, and he will be interested in the mottled aspect which it presents in certain regions, caused by ridges and elevations, which, when this sea-bottom was covered with water, may have formed shoals and islands.

The Sea of Fertility (X) is remarkable for its irregular surface, and the long, crooked bays into which its southern extremity is divided.

The Sea of Nectar (V) is connected with the Sea of Tranquillity by a broad strait (one would naturally anticipate from their names that there must be some connection between them), while between it and the Sea of Fertility runs the range of the Pyrenees Mountains, twelve thousand feet high, flanked by many huge volcanic mountain-rings.

The Sea of Serenity (H), lying northeast of the Sea of Tranquillity, is about four hundred and twenty miles broad by four hundred and thirty miles long, being very nearly of the same area as our Caspian Sea. It is deeper than the Sea of Tranquillity, and a greenish hue is

sometimes detected in its central parts. It deepens toward the middle. Three quarters of its shore-line are bordered by high mountains, and many isolated elevations and peaks are scattered over its surface. In looking at these dried-up seas of the moon, one is forcibly reminded of the undulating and in some places mountainous character of terrestrial sea-bottoms as shown by soundings and the existence of small islands in the deep sea, like the Bermudas, the Azores, and St. Helena. The Sea of Serenity is divided nearly through the center by a narrow, bright streak, apparently starting from the crater-mountain Menelaus (36 in the map), but really taking its rise at Tycho far in the south. This curious streak can be readily detected even with a small opera-glass. Just what it is no one is prepared to say, and so the author of the "Moon Hoax" was fairly entitled to take advantage of the romancer's license, and declare that "its edge throughout its whole length of three hundred and forty miles is an acute angle of solid quartz-crystal, brilliant as a piece of Derbyshire spar just brought from the mine, and containing scarcely a fracture or a chasm from end to end!" Along the southern shore, on either side of Menelaus, extends the high range of the Hæmus Mountains. South and southeast of the Sea of Serenity are the Sea of Vapors (L)*, the Central Gulf (M), and the Gulf of Heats (N). The observer will notice at full moon three or four curious dark spots in the region occupied by these flat expanses. On the north and northwest of the Sea of Serenity are the Lake of Death (D), and the Lake of Dreams (E), chiefly remarkable for their names.

The Sea of Showers (O) is a very interesting region, not only in itself, but on account of its surroundings. Its level is very much broken by low, winding ridges, and it is variegated by numerous light streaks. At its western end it blends into the Marsh of Mists (I) and the Marsh of Putrefaction (K). On its northeast border is the celebrated Sinus Iridum, or Bay of Rainbows (P), upon which selenographers have exhausted the adjectives of admiration. The bay is semicircular in form, one hundred and thirty-five miles long and eighty-four miles broad. Its surface is dark and level. At either end a splendid cape extends into the Sea of Showers, the eastern one being called Cape Heraclides, and the western Cape Laplace. They are both crowned by high peaks. Along the whole shore of the bay runs a chain of gigantic mountains forming the southern border of a wild and lofty plateau, called the Sinus Iridum Highlands. Of course, a telescope is required to see the details of this "most magnificent of all lunar landscapes," and yet much can be done with a good field-glass. With such an instrument I have seen the capes at the ends of the bay projecting boldly into the dark, level expanse surrounding them, and the high lights of the bordering mountains sharply con-

* The letter L has accidentally been misplaced in the map. It should be on the dark expanse below its present place.

trasted with the dusky semicircle at their feet, and have been able to detect the presence of the low ridges that cross the front of the bay like shoals, separating it from the "sea" outside. Two or three days after first quarter, the shadows of the peaks about the Bay of Rainbows may be seen. The Bay of Dew (R) above the Bay of Rainbows, and the Sea of Cold (C), are the northernmost of the dark levels visible. It was in keeping with the supposed character of this region of the moon that Riccioli named two portions of it the Land of Hoar Frost and the Land of Drought.

Extending along the eastern side of the disk is the great Ocean of Storms (Q), while between the Ocean of Storms and the middle of the moon lies the Sea of Clouds (S). Both of these are very irregular in outline, and much broken by ridges and mountains. The Sea of Humors (T), although comparatively small, is one of the most easily seen of all the lunar plains. To the naked eye it looks like a dark, oval patch on the moon. With a telescope it is seen, under favorable conditions, to possess a decided green tint. Humboldt Sea (B) and the South Sea (Z) belong principally to that part of the moon which is always turned away from the earth, and only their edges project into the visible hemisphere, although under favorable librations, their further borders, lined as usual with mountain-peaks, may be detected. For our purposes they possess little interest.

Let us now glance at some of the mountains and "craters." The dark oval called Grimaldi (1) can be detected by the naked eye, or at least it has been thus seen, although it requires a sharp eye; and perhaps a shade of London smoke-glass, to take off the glare of the moon, should be used in looking for it. It is simply a plain, containing some fourteen thousand square miles, remarkable for its dark color, and surrounded by mountains. Schickhard (7) is another similar plain, nearly as large, but not possessing the same dark tint in the interior. The huge mountains around Schickhard make a fine spectacle when the sun is rising upon them shortly before full moon.

Tycho (9) is the most famous of the crater-mountains, though not the largest. It is about fifty-four miles across and three miles deep, In its center is a peak five or six thousand feet high. Tycho is the radial point of the great light-streaks that, as I have already remarked, cause the southern half of the moon to be likened to a peeled orange. It is a tough problem in selenography to account for these streaks. They are best seen at full moon. They can not be seen at all until the sun has risen to a certain elevation above them, 25° according to Neison; but, when they once become visible, they dominate everything. They turn aside for neither mountains nor plains, but pass straight on their courses over the ruggedest regions of the moon, retaining their brilliancy undiminished, and pouring back such a flood of reflected light that they completely conceal some of the most stupendous mountain-masses across which they lie. They clearly consist

of different material from that of which the most of the moon's surface is composed—a material possessing a higher reflective power. In this respect they resemble Aristarchus and other lunar craters that are remarkable for their brilliancy under a high illumination. Tycho itself, the center or hub, from which these streaks radiate like spokes, is very brilliant in the full moon. But immediately around Tycho there is a dark rim some twenty-five miles broad. Beyond this rim the surface becomes bright, and the bright region extends about ninety miles farther. Out of it spring the great rays or streaks which vary from ten to twenty miles in width, and many of which are several hundred miles long—one, which we have already mentioned as extending across the Sea of Serenity, being upward of two thousand miles in length. It has been truly said that we have nothing like these streaks upon the earth, and so there is no analogy to go by in trying to determine their nature. It has been suggested that if the moon had been split or shattered from within by some tremendous force, and molten matter from the interior had been thrust up into the cracks thus formed, and had cooled there into broad seams of rock, possessing a higher reflective power than the surrounding surface of the moon, then the appearances presented would not be unlike what we actually see. But there are serious objections to such a view, which we have not space to discuss here. It is enough to say that the nature of these streaks is still a question awaiting solution, and here is an opportunity for an important discovery, but one not to be achieved with an opera-glass.

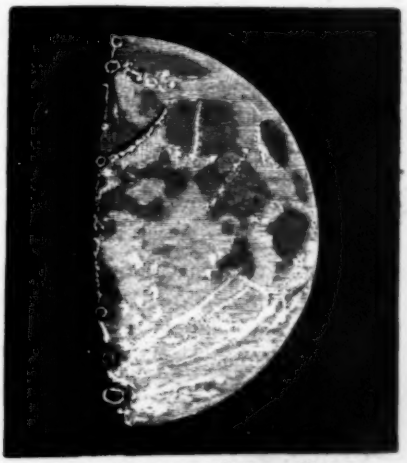


FIG. 3.—SUNRISE ON CLAVIUS, TYCHO, PLATO, ETC.

Clavius (11) is one of the most impressive of all the lunar formations. There probably does not exist anywhere upon the earth so wild a scene upon a corresponding scale of grandeur. Of course, its details are far beyond the reach of the instrument we are supposed to be using, and yet even with a field-glass, or a powerful opera-glass, some of its main features are visible. It is represented in our third illustration, being the lowest and largest of the ring-like forms seen at the inner edge of the illuminated half of the disk; the rays of the rising sun touching the summits of some of the peaks in its interior have brought them into sight as a point of light, and at the same time, reaching across the gulf within, have lighted up the higher slopes of the great mountain-wall on the farther or eastern side of the crater valley, making it re-

semble a semicircle of light projecting into the blackness of the still unilluminated plains around it. I should advise every reader to take advantage of any opportunity that may be presented to him to see Clavius with a powerful telescope when the sun is either rising or setting upon it. Neison has given a spirited description of the scene, as follows:

The sunrise on Clavius commences with the illumination of a few peaks on the western wall, but soon rapidly extends along the whole wall of Clavius, which then presents the appearance of a great double bay of the dark night-side of the moon penetrating so deep into the illuminated portion as to perceptibly blunt the southern horn to the naked eye. Within the dark bay some small, bright points soon appear—the summits of the great ring-plains within—followed shortly by similar light points near the center, due to peaks on the walls of the smaller ring-plains, these light islands gradually widening and forming delicate rings of light in the dark mass of shadow still enveloping the floor of Clavius. Far in the east then dimly appear a few scarcely perceptible points, rapidly widening into a thin bright line, the crest of the great southeastern wall of Clavius, the end being still lost far within the night-side of the moon. By the period the extreme summit of the lofty wall of Clavius on the east becomes distinct, fine streaks of light begin to extend across the dark mass of shadow on the interior of Clavius, from the light breaking through some of the passes on the west wall and illuminating the interior; and these streaks widen near the center and form illuminated spots on the floor, when both east and west it still lies deeply immersed in shadow, strongly contrasting with the now brightly-illuminated crest of the lofty east wall and the great circular broad rings of light formed by the small ring-plains within Clavius. The illumination of the interior of Clavius now proceeds rapidly, and forms a magnificent spectacle: the great brightly-illuminated ring-plains on the interior, with their floors still totally immersed in shadow; the immense steep line of cliffs on the east and southeast are now brilliantly illuminated, though the entire surface at their base is still immersed in the shades of night; and the great peaks on the west towering above the floor are thrown strongly into relief against the dark shadow beyond them.

Newton (12) is the deepest of the great crateriform chasms on the moon. Some of the peaks on its walls rise twenty-four thousand feet above the interior gulf. Its shadow, and those of its gigantic neighbors—for the moon is here crowded with colossal walls, peaks, and craters—may be seen breaking the line of sunlight below Clavius, in our third picture. I have just spoken of these great lunar formations as chasms. The word describes very well the appearance which some of them present when the line separating day and night on the moon falls across them, but the reader should not be led by it into an erroneous idea of their real character. Such formations as Newton, which is one hundred and forty miles long by seventy broad, may more accurately be described as vast depressed plains, generally containing peaks and craters, which are surrounded by a ring of steep mountains, or mountain-walls, that rise by successive ridges and terraces to a stupendous height.

The double chain of great crater-plains reaching half across the

center of the moon contains some of the grandest of these strange configurations of conjoined mountain, plain, and crater. The names of the principal ones can be learned from the map, and the reader will find it very interesting to watch them coming into sight about first quarter, and passing out of sight about third quarter. At such times, with a field-glass, some of them look like enormous round holes in the inner edge of the illuminated half of the moon. Theophilus (23), Cyrillus (24), and Catharina (25), are three of the finest walled plains on the moon—Theophilus, in particular, being a splendid specimen of such formations. This chain of craters may be seen rapidly coming into sunlight at the edge of the Sea of Nectar, in our second illustration. The Altai Mountains (26) are a line of lofty cliffs, two hundred and eighty miles in length, surmounting a high table-land.

The Caucasus Mountains (38) are a mass of highlands and peaks, which introduce us to a series of formations resembling those of the mountainous regions of the earth. The highest peak in this range is about nineteen thousand feet. Between the Caucasus and the Apennines (44) lies a level pass, or strait, connecting the Sea of Serenity with the Sea of Showers. The Apennines are the greatest of the lunar mountain-chains, extending some four hundred and sixty miles in length, and containing one peak twenty-one thousand feet high, and many varying from twelve thousand to nearly twenty thousand. It will thus be seen that the Apennines of the earth sink into insignificance in comparison with their gigantic namesakes on the moon. As this range runs at a considerable angle to the line of sunrise, its high peaks are seen tipped with sunlight for a long distance beyond the generally illuminated edge about the time of first quarter. Even with the naked eye the sun-touched summits of the lunar Apennines may at that time be detected as a tongue of light projecting into the dark side of the moon. The Alps (41) are another mountain-mass of great elevation, whose highest peak is a good match for the Mont Blanc of the earth, after which it has been named.

Plato (42) is a very celebrated dark and level plain, surrounded by a mountain-ring, and presenting in its interior many puzzling and apparently changeable phenomena which have given rise to much speculation, but which, of course, lie far beyond the reach of opera-glasses. Plato is seen in our third illustration, being the second ring from the top.

Copernicus (46) is the last of the lunar formations that we shall describe. It bears a general resemblance to Tycho, and is slightly greater in diameter; it is, however, not quite so deep. It has a cluster of peaks in the center, whose tops may be detected with a field-glass, as a speck of light when the rays of the morning sun, slanting across the valley, illuminate them while their environs are yet buried in night. Copernicus is the center of a system of light-streaks somewhat resembling those of Tycho, but very much shorter.

We must not dismiss the moon without a few words as to its probable condition. It was but natural, after men had seen the surface of the moon diversified with hills and valleys like another earth, that the opinion should find ready acceptance that beings not unlike ourselves might dwell upon it. Nothing could possibly have been more interesting than the realization of such a fancy by the actual discovery of the lunar inhabitants, or at least of unmistakable evidence of their existence. The moon is so near to the earth, as astronomical distances go, and the earth and the moon are so intimately connected in the companionship of their yearly journey around the sun, and their greater journey together with the sun and all his family, through the realms of space, that we should have looked upon the lunar inhabitants, if any had existed, as our neighbors over the way, dwelling, to be sure, upon a somewhat more restricted domain than ours, vassals of the earth in one sense, yet upon the whole very respectable and interesting people, with whom one would be glad to have a closer acquaintance. But, alas! as the powers of the telescope increased, the vision of a moon crowded with life faded, until at last the cold fact struck home that the moon is, in all probability, a frozen and dried-up globe, a mere planetary skeleton, which could no more support life than the Humboldt glacier could grow roses. And yet this opinion may go too far. There is reason for thinking that the moon is not absolutely airless, and, while it has no visible bodies of water, its soil may, after all, not be entirely arid and desiccated. There are observations which hint at visible changes in certain spots that could possibly be caused by vegetation, and there are other observations which suggest the display of electric luminosity in a rarefied atmosphere covering the moon. To declare that no possible form of life can exist under the conditions prevailing upon the lunar surface would be saying too much, for human intelligence can not set bounds to creative power. Yet, within the limits of life, such as we know them, it is probably safe to assert that the moon is a dead and deserted world. In other words, if a race of beings resembling ourselves, or resembling any of our contemporaries in terrestrial life, ever existed upon the moon, they must long since have perished. That such beings may have existed is possible, particularly if it is true, as generally believed, that the moon once had a comparatively dense atmosphere and water upon its surface, which have now, in the process of cooling of the lunar globe, been withdrawn into its interior. It certainly does not detract from the interest with which we study the rugged and beautiful scenery of the moon to reflect that if we could visit those ancient sea-bottoms, or explore those glittering mountains, we might, perchance, find there some remains or mementoes of a race that flourished, and perhaps was all gathered again to its fathers, before man appeared upon the earth.

That slight physical changes, such as the downfall of mountain-walls or crater-cones, still occasionally occur upon the moon, is an opin-

ion entertained by some selenographers, and apparently justified by observation. The enormous changes of temperature, from burning heat under a cloudless sun to the freezing cold of space at night with no atmospheric blanket to retain heat (which has generally been assumed to be the condition of things on the moon), would be expected to exert a disintegrating effect upon the lunar rocks. But the question is now in dispute whether the surface of the moon ever rises above the freezing-point of water, even under a midday sun.

THE SUN.—That spots upon the sun may be seen with no greater optical aid than that of an opera-glass is perhaps well known to many of my readers, for during the past half-dozen years public attention has been drawn to sun-spots in an especial manner, on account of their supposed connection with meteorology, and in that time there have been many spots upon the solar disk which could not only be seen with an opera-glass, but even with the unassisted eye. At present we are approaching a minimum period of sun-spots, and the number to be seen even with a telescope is comparatively very small, yet only a few days before this page was written there was a spot on the sun large enough to be conspicuous with the aid of a field-glass. During the time of a spot-maximum the sun is occasionally a wonderful object, no matter how small the power of the instrument used in viewing it may

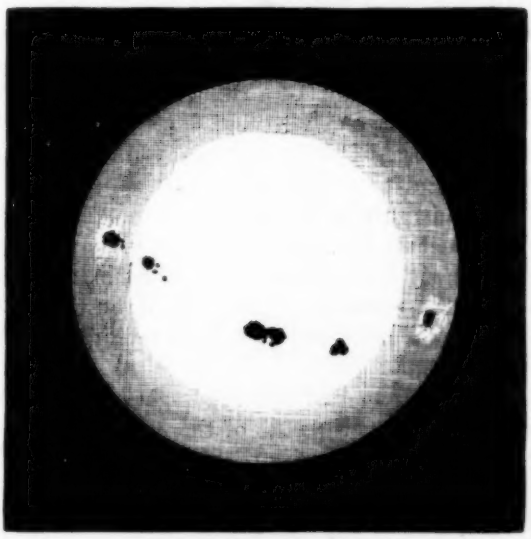


FIG. 4.—THE SUN, SEPTEMBER 1, 1883.

be. Strings of spots of every variety of shape sometimes extend completely across the disk. Our fourth illustration shows the appearance of the sun, as drawn by the author on the 1st of September, 1883. Every one of the spots and spot-groups there represented could be seen with a good field-glass, and nearly all of them with an opera-glass.

As in all such cases, our interest in the phenomena increases in proportion to our understanding of their significance and their true scale of magnitude. In glancing from side to side of the sun's disk, the eye ranges over a distance of more than 860,000 miles—not a mere ideal distance, or an expanse of empty space, but a distance filled by an actual and, so to speak, tangible body, whose diameter is of that stupendous magnitude. One sees at a glance, then, the enormous scale on which these spots are formed. The earth placed beside them would be but a speck, and yet they are mere pits in the surface of the sun, filled perhaps with partially cooled metallic vapors, which have been cast up from the interior, and are settling back again. It is worth anybody's while to get a glimpse at a sun-spot if he can, for, although he may see it merely as a black dot on the shining disk, yet it represents the play of physical forces whose might and power are there exercised on a scale really beyond human comprehension. The imagination of Milton or Dante would have beheld the mouth of hell yawning in a sun-spot.

In order to view the sun, it is, of course, necessary to contrive some protection for the eyes. This may be constructed by taking two strips of glass four or five inches long and an inch wide, and smoking one of them until you can without discomfort look at the sun through it. Then place the two strips together, with the smoked surface inside—taking care to separate them slightly by pieces of cardboard placed between the ends—and fasten the edges together with strips of paper gummed on. Then, by means of a rubber band, fasten the dark glass thus prepared over the eye-end of your opera-glass in such a way that both of the lenses are completely covered by it. It will require a little practice to enable you to get the sun into the field of view and keep it there, and for this purpose you should assume a posture—sitting, if possible—which will enable you to keep the glass very steady. Then point the glass nearly in the direction of the sun, and move it slowly about until the disk comes in sight. It is best to carefully focus your glass on some distant object before trying to look at the sun with it.

As there is some danger of the shade-glass being cracked by the heat, especially if the object-glasses of the instrument are pretty large, it would be well to get the strips of glass for the shade large enough to cover the object-end of the instrument instead of the eye-end. At a little expense an optician will furnish you with strips of glass of complementary tints, which, when fastened together, give a very pleasing view of the sun without discoloring the disk. Dark red with dark blue or green answer very well; but the color must be very deep. The same arrangement, of course, will serve for viewing an eclipse of the sun.

MANUAL TRAINING IN SCHOOL EDUCATION.

By Sir PHILIP MAGNUS.

"Manual labor is the study of the external world."—Emerson.

THE first object of education being to bring the mind of man into direct relation with its surroundings, and as this communion is only possible through the senses, the importance of the cultivation of the senses is duly insisted upon by all educational authorities. Now, of the several organs through which we obtain a knowledge of the external world, the sense of touch and the muscular sense have a certain prominence as giving us perceptions which are mainly intellectual. For this reason we should expect that the training of the muscular and tactile sensibility of the hand, and the training of the muscular sense generally, as exercised in the determination of size, shape, and resistance, would form an essential factor of education. But so little has this been the case that, until comparatively recent times, the training of the faculties by which we obtain, at first hand, our knowledge of the things about us has been sadly neglected, and education has consisted mainly in storing the memory with words, with the statements and opinions of others, and with inferences therefrom. Apart altogether from the value of the constructive power which manual skill affords, the knowledge of the properties of matter which is obtained in the acquisition of that skill is considerable, and can not be equally well acquired in any other way. It is this which gives to manual training its value as an educational discipline, and it is mainly for this reason that it is coming to be regarded as an important part of the educational system of nearly every country. "The introduction of manual work into our schools is important," says Sir John Lubbock, "not merely from the advantage which would result to health, not merely from the training of the hand as an instrument, but also from its effect on the mind itself."* And it is to this effect on the mind that I desire to call especial attention in this article.

By manual training one commonly means exercises in the use of the tools employed in working wood and iron.

It can not be too often repeated that the object of workshop practice, as a part of general education, is not to teach a boy a trade, but to develop his faculties and to give him manual skill; that, although the carpenter's bench and the turner's lathe are employed as instruments of such training, the object of the instruction is not to create carpenters or joiners, but to familiarize the pupil with the properties of such common substances as wood and iron, to teach the hand and eye to work in unison, to accustom the pupil to exact measurements,

* "Fortnightly Review," October, p. 467.

and to enable him by the use of tools to produce actual things from drawings that represent them. The discipline of workshop instruction may be regarded as supplementary to that of drawing, with which, however, it should always be associated, as teaching a knowledge of *substance* in addition to that of *form*. Moreover, under competent instructors, it may be made an instrument of education similar, in many respects, to practical science. In the workshop, the operations to be performed are less delicate, the measurements are not required to be so exact, the instruments are more easily understood, the substances employed are more ordinary; but the training is very similar, and in so far as the faculties exercised are those of observation rather than of inference, the training, educationally considered, is a fitting introduction to laboratory practice. At the same time, the skill acquired in the workshop is particularly serviceable to the laboratory student in enabling him to make and fit apparatus, and in giving him that adroitness on which progress in scientific work so much depends. But while a certain amount of manual training is valuable in the education of all classes of persons—a fact which is already recognized by the head-masters of several of our best secondary schools—the usefulness of this kind of training is much greater in the case of the children of the working-classes, whose education is too limited and often too hurried to admit of any practical science-teaching, such as older children obtain, and to whom the skill acquired is of real advantage in inducing in them an aptitude and taste for handicrafts, in facilitating the acquisition of a trade, and possibly in shortening the period of apprenticeship, or of that preliminary training which in so many occupations takes the place of it.

An objection is sometimes raised to the introduction of manual training into elementary schools on the ground that, as the children of the working-classes necessarily leave school at an early age, and spend their lives for the most part in manual work, such time as they can give to study should be occupied in other pursuits—in cultivating a taste for reading, and in the acquisition of book-knowledge. This objection is due to a misconception of the true objects and aims of education, and to an imperfect knowledge of what is meant by workshop instruction. To assume that the best education can be given through the medium of books only, and can not be equally well obtained from the study of things, is a survival of the mediævalism against which nearly all modern educational authorities protest. But there is another and more deeply-rooted error in this argument. People often talk and write as if school-time should be utilized for teaching those things which a child is not likely to care to learn in after-life; whereas the real aim of school education should be to create a desire to continue in after-life the pursuit of the knowledge and the skill acquired in school. In other words, the school should be made, as far as possible, a preparation for the whole work of life, and should

naturally lead up to it. The endeavor of all educators should be to establish such a relation between school instruction and the occupations of life as to prevent any break of continuity in passing from one to the other. The methods by which we gain information and experience in the busy world should be identical with those adopted in schools.

It is because the opposite theory has so long prevailed, that our school-training has proved so inadequate a preparation for the real work of life. This was not the case in former times ; and the demand for technical instruction, both in our elementary and in our secondary schools, is a protest against the contrast which has so long existed between the subjects and methods of school-teaching and the practical work of every-day life.

We are always justly complaining that in this country children leave school at too young an age, before they can have had time to properly assimilate the knowledge they have acquired, with the result that they soon forget a great part of the little they have learned. At the age of fifteen or sixteen, when they begin to feel the want of technical instruction, they are wholly unprepared to avail themselves of the opportunities for obtaining it now brought within their reach. It is to remedy this state of things that continuation schools and recreative classes are much needed. But there can be little doubt, if elementary education were made more practical, that parents would be more willing, even at some sacrifice, to let their children benefit by it. They are often led to take their children away from school, because they do not see much use in the "schooling." Of course, the desire to secure the child's early earnings operates in very many cases ; but I am convinced that it would be easier to persuade parents to forego these earnings, if the school-teaching had more direct reference to the work in which the children are likely to be subsequently occupied.

Now, in order that manual training may serve the purpose of an intellectual discipline, the methods of instruction must be carefully considered. That the training of the hand and eye, and the development of the mental faculties, are the true objects of the instruction should never be lost sight of. In many respects, the instruction should partake of the character of an ordinary object-lesson. Before the pupil commences to apply his tools to the material in hand, he should learn something of its nature and properties. The teacher, in a few words introductory to each lesson, should explain to his pupils the distinguishing characteristics of different kinds of wood, as met with in the shop and as found in Nature, and also the differences in the structure and properties of wood according to its sections, treatment, etc. And he should illustrate his lessons by reference to specimens and examples, a collection of which should be found in every school workshop. Something should be said of the countries from which timber is imported, and the conditions under which it is bought and sold, and in

this way the material to be manipulated should be made the center of a series of scientific object-lessons.

Concurrently with the practice in the use of any tool, the pupil should learn its construction, the reason of its shape, and the history of its development from other simpler forms. The saw, the plane, the chisel, and the calipers should each be made the subject of an object-lesson to the pupils. In the same way, the teacher should explain the purposes of the different parts of constructive work, and should have models of tenon, mortise, dovetailing, and other joints to illustrate his explanations.* Fifteen or twenty minutes thus spent might be made the means of stimulating the intelligence and of exercising the observing and reasoning faculties of the children, and of enabling them to fully understand the work they are doing and the instruments they are using.

Further, the children should be taught, from the very first, to work from correct scale-drawings, made by themselves from their own rough sketches. How simple soever the object may be which the pupil is to construct, it should exactly correspond with his own drawings. In this way, the workshop instruction supplements and gives a meaning to the drawing-lesson, and the school-teaching is made to have a direct bearing upon the subsequent work of the artisan. Dr. Woodward, the instructor of the St. Louis Manual Training-School, who has had considerable experience in organizing and superintending workshop instruction, tells us that "the habit of working from drawings and to nice measurements gives to students confidence in themselves altogether new"; and he justly claims that "it is the birthright of every child to be taught the three methods of expression: 1. By the written, printed, or spoken word. 2. By the pencil and brush, using the various kinds of graphic art. 3. Through the instrumentality of tools and materials, which enable one to express thought in the concrete."† The Committee of Council on Education, in their recent report, speaking of the teaching of cooking to girls, say: "After the three elementary subjects and sewing, no subject is of such importance for the class of girls who attend public elementary schools, and lessons in it, if properly given, will be found to be not only of practical use, but to have the effect of awakening the interest and intelligence of the children." Surely, what is true of sewing and cooking in the case of girls, is true to a greater extent of drawing and handicrafts in the case of boys.

In many parts of the Continent manual training has now for some years been associated with elementary instruction. In France, Belgium, Austria, Holland, and Sweden the workshop is a part of the school-building; and in the United States the number of manual training-schools of higher grade, somewhat similar to the well-known ap-

* Collections of these models for school purposes are sold by Messrs. Schröder, of Darmstadt.

† "Proceedings of International Conference on Education," London, 1884, vol. ii, p. 58.

prenticeship-schools of France, is steadily increasing. Indeed, judging from the published accounts of these schools, and from the writings of some of the most prominent educationists in the United States, an enthusiasm is spreading among Americans in favor of workshop instruction, which is likely to have an important influence on the industrial progress of this eminently practical and inventive people.

In the report of the Commissioners on Technical Instruction, notices will be found of some of the principal Continental schools which are now fitted with workshops. Sir John Lubbock, in the article above quoted, has supplemented this information by reference to the "Slöjd" system of manual instruction which is adopted in Sweden. An interesting account of this system has been written by M. Sluys, who is well known to educationists from his connection with the École Modèle of Brussels. Since the report of the commissioners was published, the movement in favor of workshop-teaching in schools has advanced rapidly in France. Nearly every large town has now its higher elementary school (a type of school as yet scarcely to be found in this country) fitted with workshops for wood and iron; and, out of one hundred and seventy-four primary schools supported by the city of Paris, ninety-five are now provided with workshops, ninety for instruction in carpentry and wood-turning, and five for metal-work. In these schools the manual teaching has hitherto been given either before or after the ordinary school-hours; but the Municipal Council of Paris attach such importance to this training that it is proposed to make the workshop instruction a part of the regular school curriculum. This change will necessitate a rearrangement of the school-hours and the provision of workshops in the remaining seventy-nine schools in which they have not yet been fitted. But it is confidently expected that the municipality of Paris, which has done so much for the technical education of its artisans, will not hesitate to incur this additional expense. The action of the city of Paris gives additional weight to the recommendation of the English commissioners on this subject.

Experiments of introducing workshops into elementary schools have been tried in this country, with results sufficiently encouraging to justify the extension of the system. In Sheffield, Birmingham, and Glasgow the results have been eminently satisfactory. In London the experiment has recently been tried on a small scale, and under not the most favorable circumstances, in the Beethoven Street schools; but the report of Mr. Tate, the energetic head-master, is so encouraging that the School Board of London is very desirous of extending the system of instruction to a large number of the schools under its control. In his report to the board, Mr. Tate says:

> This class was started on September 28, 1885, in a shed or workshop, built by the board in a recess in the playground, and the instruction is given by the school-keeper, a carpenter by trade, under the direct supervision of the head-master.

The boys are chosen mainly from the seventh standard, and attendance at the workshop is considered a privilege, and a reward of merit in ordinary school subjects. It is therefore a simulus and incentive to industry and thoroughness of work. This plan has been so effective that a boy once chosen values the teaching and practice so much that he continues to be chosen each week, and the instruction is therefore continuous, for the class has been virtually the same since it started.

Boys who have been trained in a good school, and have acquired soundly the rudiments of education, too often when they leave school think that their proper career is a city counting-house, and that to wear black clothes and appear as a gentleman is a fair summit of their ambition. I certainly think that this workshop for upper standard boys will help to dissipate this idea, as it will show boys that, after we have given them the best education which the school offers, we then lead them into the workshop, and so practically show them that the end and aim of our training is to enable them to learn some useful trade, and so become good workmen.

The workshop, I believe, is a valuable training to enable the eye and hand to work in harmony. It is intended to make the school-drawing, especially the scale-drawing and geometry, apply as much as possible to the work done in the workshop. It is certainly a pleasant relief to ordinary school-work. Should a boy not follow a trade when he leaves school, he will at least be able to make his home-work comfortable by using the skill and facility which he has acquired in this workshop.

At the expense of the Rev. S. Barnett and a few of his friends, a workshop has recently been fitted in the school attached to St. Jude's Church, Whitechapel. Arrangements have been made for giving instruction in carpentry and turnery to boys, and in modeling and wood-carving to girls of the upper standards, and the results of the lessons have fully justified the most sanguine expectations of the advocates of this kind of instruction. Those who have visited these schools have been struck with the cheerful interest shown by the children in their work, and by the effect of the teaching in quickening their perceptive faculties and in stimulating their intelligence. The contrast between the listless and often inattentive attitude of children, occupied with some ordinary class lesson, and the eager eyes and nimble fingers of the same children at the carpenter's or modeling bench is most instructive; and no one who has seen it can have any doubt of the educational value of this kind of training. These results, it must be remembered, have been attained by teachers most of whom have themselves been trying experiments, and have been working by the light of Nature without any well-considered methods. Under properly-trained instructors, the results would doubtless have been far more satisfactory.

There is good reason to believe that the stimulating effect of workshop instruction on the intelligence of children will be such that, notwithstanding the loss of the time spent in the shop, their progress in their ordinary studies will be in no way retarded.

Mr. Swire Smith, a member of the late Commission on Technical

Instruction, states "that the half-time children of the town of Keighley, numbering from fifteen hundred to two thousand, although they receive less than fourteen hours of instruction per week, and are required to attend the factory for twenty-eight hours per week in addition, yet obtain at the examinations a higher percentage of passes than the average of children throughout the whole country receiving double the amount of schooling." This answers the objection so often raised, that the curriculum of elementary schools is already overcrowded. Possibly it may be with literary studies, but not with practical work, and the combination of the two will go far to correct the tendency to over-pressure inherent in our system of payment by results.

As a general rule, children should be required to have passed the fifth standard before being admitted into the shop. They should receive two lessons a week, and each lesson should be of about two hours' duration. No fixed rule can at present be given as to the number of children who can be taught by one instructor. For convenience of supervision the shop should be fitted for the accommodation of not more than twenty-five children. On starting a class, each pupil requires more individual attention than later on. A class of beginners, therefore, should not consist of the full complement of children. Where the same shop is used for bench-work and lathe-work, it will be found that a double lathe will occupy four pupils, that eighteen can be accommodated at three carpenters' benches, each of not less than fourteen feet six inches in length, while two may be engaged in sawing. Besides the benches and lathes, the school should contain a large blackboard, a cupboard, which is better than boxes for holding tools, and a grindstone.

In estimating the expense of adding this subject to our elementary school course, we have to consider the cost—first, of equipping the workshops; second, of the material used; third, of the teaching.

Supposing a shed or some other room to be found, which can be used as a workshop, the cost of equipping the shop with benches and with the necessary tools need not exceed thirty shilling for each pupil's place, and the workshop can be used by different sets of pupils at different times. Moreover, a shop need not be fitted at once with the full complement of benches; for, after a time, the more advanced pupils may be employed in making some of the additional fittings required.

The cost of material is inconsiderable. The children soon learn to construct various articles for their own homes, which, on payment of the cost of the material consumed, become the property of their parents. Some, too, might be employed in making models and other objects, including certain workshop-fittings, which might be purchased for the use of other schools. At the same time, care must be taken that the work is always subordinated to the educational purpose of the instruction.

Of the actual cost of the teaching no very exact estimate can as

yet be formed. Much depends on the system adopted. If the instruction were given during school-hours, it would take the place of some other lesson, and, by a proper arrangement of time-tables, might be given at very little additional expense. In some of the schools in which the experiment has been already tried, special teachers have been appointed, who have received a certain fee for each lesson. But if several schools in the same district combined, one teacher might be engaged, and either the children might be brought to a common center, as in the case of the cookery-classes, or the teacher might go from school to school, as in the case of the science-teaching in Birmingham and Liverpool. The latter plan might be more convenient for the schools; but the former plan would be more economical, as enabling one shop and certain tools to be used by several sets of children.

It would be necessary under any circumstances that the instruction should be encouraged by a system of grants, or by some equivalent external aid. A system might be organized of paying grants on the results of the individual work of each pupil; but all the disadvantages of the method of "payment by results" would be emphasized in the case of workshop instruction, and the teaching would lose much of its disciplinary value. The amount of the grant should depend mainly on the average number of children in attendance. A grant of four shillings, as in the case of cookery-lessons, and the recognition of the subject by the Education Department, would afford sufficient encouragement to induce certain school boards and school managers to make manual training a part of the curriculum of the schools under their control. The total amount of these grants would be but a slight addition to our education expenses. According to the last report, the whole number of children presented for examination in the sixth and seventh standards was 112,455. Of these, we may assume that about 60,000 are boys. Supposing half this number to elect to receive workshop instruction, the grant would amount to £6,000 a year. But even this estimate is excessive as an addition to our present expenditure. For many of the children might take handicrafts in lieu of one of the specific subjects on which grants are now paid.* It may, therefore, I think, be asserted that, the workshops being once equipped, the additional cost in grants of introducing handicraft teaching into the curriculum of our elementary schools would not exceed £5,000 a year; and for this comparatively small expenditure about 30,000 boys might be annually sent out into the world from our elementary schools endowed with practical skill at their fingers' ends, imbued with a taste

* It may be well here incidentally to call attention to the relatively small amount of grants earned for specific subjects. Out of 352,860 children, who last year were examined in elementary subjects in the fifth, sixth, and seventh standards, only 64,376 presented themselves in specific subjects, the total amount of grant paid being £14,662 11*s.* 8*d.* Of the children on account of whom these grants were earned, Sir John Lubbock tells us that less than 25,000 were examined in any branch of science.

and aptitude for the real work of their life, and so educated as to be able to apply to that work the results of scientific teaching and scientific methods.

In organizing a scheme of technical teaching in connection with our elementary schools, the difficulty has to be met of obtaining good teachers and competent inspectors. The artisan, who is a skillful workman and nothing more, may succeed in teaching the elements of carpentry and joinery; but he is not the kind of teacher needed. It is of the utmost importance that the instructor should be a good draughtsman, should have some knowledge of physical science, should be an expert workman, and should have studied the art of teaching. To obtain at first such ideal instructors would be impossible; but there is no reason why, gradually, they should not be trained. Two processes suggest themselves. We might take a well-trained elementary teacher, having an aptitude for mechanical arts, and give him a course of instruction in the use of tools, either in a technical school or in an ordinary workshop; or, we might take an intelligent artisan, who had studied science and drawing in some of the excellent evening classes which are now found in almost every town, and give him a short course of lessons on method in relation to workshop instruction. Good teachers might be obtained by either of these processes. Perhaps the latter is preferable, as it is most important that the teacher who is to inspire confidence should be a good workman to start with and thoroughly familiar with the practice of his trade. For such intelligent and educated artisans there is, I hope, a future of profitable employment. It would be well, however, that in all our technical colleges opportunities should be afforded to teachers in elementary schools of acquiring practice in the use of tools; and that special training-classes should be formed for artisans, in the organization of workshops and in the best methods of workshop teaching.

Nearly all educationists have pointed out the many advantages of enabling children at an early age to realize the connection between *knowing* and *doing*. Comenius has well said, "Let those things that have to be done be learned by doing them." Rousseau has pithily expressed a similar idea in saying: "Souvenez-vous qu'en toute chose vos leçons doivent être plus en actions qu'en discours; car les enfants oublient aisément ce qu'ils ont dit et ce qu'on leur a dit, mais non pas ce qu'ils ont fait et ce qu'on leur a fait." (Remember that in everything your lessons ought to be more in actions than in speech; for children easily forget what they have said and what has been said to them, but not what they have done and what has been done to them.) Locke, speaking of the education of a gentleman—for in his day the education of the poorer classes was scarcely thought of—says, "I would have him learn a trade, a manual trade"; and Emerson, in the choice words, "Manual labor is the study of the external world,"

tersely states the whole aim and purpose of my remarks. Rabelais, Montaigne, Pestalozzi, Froebel, Combe, Spencer, and others have urged the importance of practical teaching, of studying things before words, of proceeding from the concrete to the abstract. But, as yet, such has been the inertia of school authorities and teachers, and such the force of tradition, that we are only now beginning to employ the methods of instruction that have been advocated for years by the most eminent educational reformers.

In what I have said, I have endeavored to show that workshop instruction may be made a part of a liberal education; that, as an educational discipline, it serves to train the faculties of observation, to exercise the hand and eye in the estimation of form and size, and the physical properties of common things; that the skill acquired is useful in every occupation of life, and is especially serviceable to those who are likely to become artisans, by inducing taste and aptitude for manual work, by tending to shorten the period of apprenticeship, by enabling the learner to apply to the practice of his trade the correct methods of inquiry which he has learned at school, and by affording the necessary basis for higher technical education.

Possibly, the latest authoritative expression of opinion on the importance of manual training was a resolution, unanimously agreed to at the International Congress on Commercial and Technical Education, recently held at Bordeaux, to the effect that it is desirable that manual work should be rendered obligatory in primary schools of all grades.

It is satisfactory to know, from a circular* that has recently been sent to school managers, that this important subject is engaging the serious attention of the Royal Commission on Education now sitting, whose labors, it is to be hoped, may result in making our elementary teaching more practical, less mechanical, and better adapted to the future requirements of the working-classes.— *Contemporary Review.*

* The circular, as published by Lord Brabazon in a letter to the "Times" of October 11th, contains the following questions:

1. Is the course of teaching prescribed by the Code suited to the children of your school?

2. What changes, if any, would you desire in the (Education Acts)? in the Code? in the administration?

3. Would you recommend the introduction into your school of practical instruction? A. In any of the industries of the district? or in the use of tools for working in wood or iron? B. (for girls) in the domestic duties of home?

Baron Eggers is about to undertake the botanical investigation of the hitherto unexplored higher mountains of Santo Domingo. He is under commission of Dr. Urban, assisted by the Royal Academy of Sciences of Berlin. Collections will be distributed in limited numbers, at prices bearing relation to the novelty of the species.

THE PROGRESS OF SCIENCE FROM 1836 TO 1886.

By GRANT ALLEN.

FIFTY years ago, science was still inchoate. Much had already been done by the early pioneers. The ground had been cleared; the building-materials had been in part provided; the foundations had been duly and ably laid; but the superstructure as yet had hardly been raised a poor foot or two above the original level. The work of the last half-century has been twofold. On one side it has been accumulative merely: new stocks of organizable material—the raw bricks of science—have been laid up, as before, ready to the call of the master-mason, but in far greater profusion than by any previous age. On the other side it has been directive and architectonic; the endless stores of fact and inference, thus dug out and shaped to the hand by the brick-makers of knowledge in a thousand fields, have been assiduously built up by a compact body of higher and broader intelligences into a single grand harmonious whole. This last task forms, indeed, the great scientific triumph of our epoch. Ours has been an age of firm grasp and of wide vision. It has seen the downfall of the anthropocentric fallacy. Cosmos has taken the place of chaos. Isolated facts have been fitted and dovetailed into their proper niche in the vast mosaic. The particular has slowly merged into the general, the general into still higher and deeper cosmical concepts. We live in an epoch of unification, simplification, correlation, and universality. When after-ages look back upon our own, they will recognize that in science its key-note has been the idea of unity.

Fifty years ago, there were many separate and distinct sciences, but hardly any general conception of science at large as a single, rounded, and connected whole. Specialists rather insisted pertinaciously on the utter insularity of their own peculiar and chosen domain. Zoölogists protested, with tears in their eyes, that they had nothing to do with chemistry or with physics; geologists protested with a shrug of their shoulders, that they had nothing to do with astronomy or with cosmical genesis. It was a point of honor with each particular department, indeed, not to encroach on the territory of departments that lay nearest to it. Trespassers from the beaten path of the restricted science were prosecuted with the utmost rigor of the law. And within the realm of each separate study, in like manner, minor truths stood severely apart from one another; electricity refused to be at one with magnetism, and magnetism was hardly on speaking terms with the voltaic current. Organization and subordination of part to whole had scarcely yet begun to be even aimed at. The sciences were each a huge congeries of heterogeneous

facts or unassorted laws; they waited the advent of their unknown Newtons to fall into systematic and organic order.

In the pride of our hearts, we forget for the most part how very young science still is. We—who have seen that infant Hercules strangling serpents almost from its very cradle; we, who have beheld it grow rapidly under our own eyes to virile maturity and adult robustness of thew and muscle—we forget how new a power it is in the world, and how feeble and timid was its tender babyhood in the first few decades of the present century. Among the concrete sciences, astronomy, the eldest-born, had advanced furthest when our age was still young. It had reached the stage of wide general laws and evolutionary aspirations. But geology had only just begun to emerge from the earliest plane of puerile hypothesis into the period of collection and colligation of facts. Biology, hardly yet known by any better or truer name than natural history, consisted mainly of a jumble of half-classified details. Psychology still wandered disconsolate in the misty domain of the abstract metaphysician. The sciences of man, of language, of societies, of religion, had not even begun to exist. The antiquity of our race, the natural genesis of arts and knowledge, the origin of articulate speech, or of religious ideas, were scarcely so much as debatable questions. Among sciences of the abstract-concrete class, physics, unilluminated by the clear light of the principles of correlation and conservation of energy, embraced a wide and ill-digested mass of separate and wholly unconnected departments. Light had little enough to do with heat, and nothing at all to do in any way with electricity, or sound, or motion, or magnetism. Chemistry still remained very much in the condition of Mrs. Jellaby's cupboard. Everywhere science was tentative and invertebrate, feeling its way on earth with hesitating steps, trying its wings in air with tremulous fear, in preparation for the broader excursions and wider flights of the last three adventurous decades.

The great campaign of the unity and uniformity of Nature was the first to be fought, and in that campaign the earliest decisive battle was waged over the bloody field of geology. In 1837—to accept a purely arbitrary date for the beginning of our epoch—Lyell had already published his sober and sensible "Principles," and the old doctrine of recurrent catastrophes and periodical cataclysms was tottering to its fall in both hemispheres. Wholesale destructions of faunas and floras, wholesale creations of new life-systems, were felt to be out of keeping with a humane age. Drastic cosmogonies were going out of fashion. But even the uniformitarianism for which Lyell bravely fought and conquered, was, in itself, but a scrappy and piecemeal conception side by side with the wider and far more general views which fifty years have slowly brought to us. One has only, to open the "Text-Book of Geology," by Lyell's far abler modern disciple, Archibald Geikie, in order to see the vast advance made in our ideas as to the world's his-

tory during the course of the last half-century. The science of the earth's crust no longer stands isolated as a study by itself: it falls into its proper place in the hierarchy of knowledge as the science of the secondary changes, induced under the influence of internal forces and incident energies, on the cooling and corrugated surface of a once incandescent and more extended planet. I know no better gauge of the widening which comes over the thoughts of men with the processes of the suns than to turn from the *rudis indigestaque moles* of the "Principles" and the "Elements" (great as they both were in their own day) to the luminous, lucid, and comprehensive arrangement of Geikie's splendid and systematic "Text-Book." The one is an agreeable and able dissertation on a number of isolated and floating geological facts; the other is a masterly and cosmically-minded account of the phenomena observable on the outer shell of a cooling world, duly considered in all their relations, and fully co-ordinated with all the chief results of all elder and younger sister sciences.

The battle of uniformitarianism itself, however, was but a passing episode in the great evolutionary movement. That movement began along several distinct lines toward the close of the previous century, and only at last consciously recognized its own informing unity of purpose some thirty-five years ago. From another point of view—in connection with its influence upon thought at large—the evolutionary crisis has been treated elsewhere in this review by a philosophic thinker; but in its purely scientific aspect it must also be briefly considered here, forming, as it does, the acknowledged mainspring of all living and active contemporary science.

Evolution is not synonymous with Darwinism. The whole immensely exceeds the part. Darwinism forms but a small chapter in the history of a far vaster and more comprehensive movement of the human mind. In its astronomical development evolution had already formulated itself with perfect distinctness before the period with which we have here especially to deal. The nebular theory of Kant and Laplace was the first attempt to withdraw the genesis of the cosmos from the vicious circle of metaphysical reasoning, and to account for it by the continuous action of physical and natural principles alone. Our own age has done much to cast doubt upon the unessential details of Kant's rough conception, but, in return, it has made clearer than ever the fundamental truth of its central idea—the idea that stars, and suns, and solar systems, consist of materials once more diffusely spread out through space and now aggregated around certain fixed and definite nuclei by the gravitative force inherent in their atoms and masses. As these masses or atoms drew closer together in union around the common center, their primitive potential energy of separation (frankly to employ the terminology of our own time) was changed, first into the kinetic energy of molar motion in the act of union, and then into the kinetic energy of molecular motion or heat,

as they clashed with one another in bodily impact around the central core. Each star, thus produced, forever gathers in materials from its own outlying mass, or from meteoric bodies, upon its solidifying nucleus, and forever radiates off its store of associated energy to the hypothetical surrounding ether. The fullest expression of this profound cosmical conception has been given in our own time by Tait and Balfour Stewart, working in part upon the previous results of Kant. Laplace, the Herschels, Mayer, Joule, Clerk Maxwell, and Sir William Thomson. Deeply altered as the nebular hypothesis has been by the modern doctrine of correlation and conservation of energies, and by modern researches into the nature of comets, meteors, and the sun's envelopes, it still remains in its ultimate essence the original theory of Kant and Laplace.

Science has thus, within the period of our own half-century, exhibited to us the existing phase of the universe at large in the light of an episode in a single infinite and picturable drama, setting out long since from a definite beginning, and tending slowly to a definite end. Other phases, inconceivable to us, may or may not possibly have preceded it; yet others, equally inconceivable, may or may not possibly follow. But as realizable to ourselves, within our existing limitations, the physical universe now reveals itself as starting in a remote past from a diffuse and perhaps nebulous condition, in which all the matter, reduced to a state of extreme tenuity, occupied immeasurably wide areas of space, while all the energy existed only in the potential forms as separation of atoms or molecules; and the evidence leads us to look forward to a remote future when all the matter shall be aggregated into its narrowest possible limits, while all the energy, having assumed the kinetic mode, shall have been radiated off into the ethereal medium. Compared to the infinite cosmical vistas thus laid open before our dazzled eyes, all the other scientific expansions of our age shrink into relative narrowness and insignificance.

As in the cosmos so in the solar system itself, evolutionism has taught us to regard our sun, with its attendant planets and their ancillary satellites, all in their several orbits, as owing their shape, size, relations, and movements, not to external design and deliberate creation, but to the slow and regular working out of physical laws, in accordance with which each has assumed its existing weight, and bulk, and path, and position.

Geology here takes up the evolutionary parable, and, accepting on trust from astronomy the earth itself as a cooling spheroid of incandescent matter, it has traced out the various steps by which the crust assumed its present form, and the continents and oceans their present distribution. Lyell here set on foot the evolutionary impulse. The researches of Scrope, Judd, and others into volcanic and hypogene action, and the long observations of geologists everywhere on the effects of air, rain, ice, rivers, lakes, and oceans, have resulted in

putting dynamical geology on a firm basis of ascertained fact. The heated interior has been shown almost with certainty to consist of a rigid and solid mass, incandescent, but reduced to solidity under the enormous pressure of superincumbent rocks and oceans. The age of the earth has been approximately measured, at least by plausible guess-work; and the history of its component parts has been largely reconstructed. Structural and stratigraphical geology have reached a high pitch of accuracy. It is beginning to be possible, by convergence of evidences, as the American geologists have shown, and as Geikie has exemplified, to rewrite in part the history of continents and oceans, and to realize each great land-mass as an organic whole, gradually evolved in a definite direction and growing from age to age by regular accretions. Where the old school saw cataclysms and miracles, vast submergences and sudden elevations, the new school sees slow development and substantial continuity throughout enormous periods of similar activity.

It would be impossible to pass over in silence, in however brief a *résumé*, the special history of the glacial epoch theory—a theory referring indeed only to a single episode in the life of our planet, but fraught with such immense consequences to plants and animals, and to man in particular, that it rises into very high importance among the scientific discoveries of our own era. Demonstration of the fact that the recent period was preceded by a long reign of ice and snow, in the northern and southern hemispheres alike, we owe mainly to the fiery and magnetic genius of Agassiz; and the proof that this glacial period had many phases of hotter and colder minor spells has been worked up in marvelous detail by James Geikie and other able coadjutors. Its theoretic explanation, its probable causes, and its alternation in the northern and southern hemispheres by turns, have been adequately set forth by Croll in a profoundly learned and plausible hypothesis. Upon the glacial epoch depend so many peculiarities in the distribution of plant and animal forms at the present day that it has come to assume a quite exceptional importance among late geological and biological theories. Standing at the very threshold of the recent period, the great ice age forms the fixed date from which everything in modern Europe and America begins—it is the real flood which stands to the true story of our continent and our race in the same relation as the Noachian deluge stood to the imagined or traditional world of our pre-scientific ancestors. Modern history begins with the glacial epoch.

The science of life has been even more profoundly affected by the evolutionary impulse than the concrete sciences of inorganic totals. In 1837 biology as such hardly existed; zoölogy and botany, its separate components, were still almost wholly concerned with minute questions of classification; "vital force" and other unimaginable metaphysical entities were the sole explanations currently offered of all the

phenomena of plant and animal life. But Charles Darwin had then just returned from the cruise of the Beagle, and was revolving slowly in his own mind the observations and ideas which blossomed out at last into the "Origin of Species." The germs of evolutionism were already in the air. Lamarck's crude speculations had aroused the attention of all the best biological intellects of the era. Before long Chambers published the "Vestiges of Creation," and Herbert Spencer was hard at work upon the groundwork of the "System of Synthetic Philosophy." The paleontological work of Agassiz, Barraude, Owen, and others, and the general advance in knowledge of comparative anatomy and embryology, paved the way for the triumph of the new ideas; while simultaneously the dry bones of botany were being kindled into life by a younger school of workers in many French and German gardens and laboratories. With the appearance of the "Origin of Species" in 1859, the new departure definitely began. In twenty years the whole world was converted *en bloc*. Evolution on the organic side has been chiefly expounded in England by Darwin, Huxley, Spencer, and Wallace; and on the whole, though of world-wide acceptance, it has been a peculiarly English movement. Hitherto, indeed, we Britons have been remarkable as the propounders of the deepest and wisest scientific generalizations: it is only of late years that our bookish educators of the new school have conceived the noble ambition of turning us all into imitation Germans.

Life thus falls into its proper place in the scheme of things as due essentially to the secondary action of radiated solar energy, intercepted on the moist outer crust of a cooling and evolving planet. Its various forms have been gradually produced, mainly by the action of natural selection or survival of the fittest on the immense number of separate individuals ejected from time to time by pre-existing organisms. How the first organisms came to exist at all we can as yet only conjecture; to feeble and unimaginative minds the difficulty of such a conjecture seems grotesquely exaggerated; but granting the existence of a prime organism or group of organisms plus the fact of reproduction with heredity and variations, and the tendency of such reproduction to beget increase in a geometrical ratio, we can deduce from these simple elementary factors the necessary corollary of survival of the fittest, with all its far-reaching and marvelous implications. Our age has discovered for the first time the cumulative value of the infinitesimal. "Many a little makes a mickle"; that was Lyell's key in geology, that was Darwin's key in the science of life. Herbert Spencer's "Principles of Biology" most fully sum up this whole aspect of evolution as applied to the genesis of organic beings.

In 1837, the science of man, and the sciences that gather round the personality of man, had scarcely yet begun to be dreamed of. But evolutionism and geological investigation have revolutionized our conception of our own species and of the place which it holds in the

hierarchy of the universe. At the very beginning of our fifty years, Boucher de Perthes was already enthusiastically engaged in grubbing among the drift of Abbeville for those rudely-chipped masses of raw flint which we now know as palæolithic hatchets. Lyell and others meanwhile were gradually extending their ideas of the age of our race on earth; and accumulations of evidence, from bone-caves and loess, were forcing upon the minds of both antiquaries and geologists the fact that man, instead of dating back a mere trifle of six thousand years or so, was really contemporary with the mammoth, the cave-bear, and other extinct quaternary animals. The mass of proofs thus slowly gathered together in all parts of the world culminated at last in Lyell's epoch-making "Antiquity of Man," published three years after Darwin's "Origin of Species." Colenso's once famous work on the Pentateuch had already dealt a serious blow from the critical side at the authenticity and literal truth of the Mosaic cosmogony. It was the task of Lyell and his coadjutors, like Evans, Keller, and Christy and Lartet, to throw back the origin of our race from the narrow limits once assigned it into a dim past of immeasurable antiquity. Boyd Dawkins, James Geikie, Huxley, Lubbock, De Mortillet, and Bourgeois have aided in elucidating, confirming, and extending this view, which now ranks as a proved truth of paleontological and historical science.

Darwin's "Descent of Man," published some years later, was an equally epoch-making book. Lubbock's "Prehistoric Times," sent forth in 1865, and "Origin of Civilization," in 1870, had familiarized men's minds with the idea that man, instead of being "an archangel ruined," had really started from the savage condition, and had gradually raised himself to the higher levels of art and learning. Tylor's "Early History of Mankind," followed a little later by his still more important work on "Primitive Culture," struck the first note of the new revolution as applied to the genesis of religious concepts. McLennan's "Primitive Marriage" directed attention to the early nature and relations of the tribe and family. Wallace's essay on the "Origin of Human Races," and Huxley's valuable work on "Man's Place in Nature," helped forward the tide of naturalistic explanation. And by the time that Darwin published his judicial summing up on the entire question of man's origin, the jury of scientific opinion throughout the world had pretty well considered its verdict on all the chief questions at issue.

The impetus thus given to the sciences which specially deal with man, has been simply incalculable. Philology has been revolutionized. Language has told us a new story. Words, like fossils, have been made to yield up their implicit secrets. Prehistoric archæology has assumed a fresh and unexpected importance. The history of our race, ever since tertiary times, and throughout the long secular winters of the glacial epoch, has been reconstructed for us from drift and bone-cave,

from barrow and picture-writing, with singular ingenuity. Anthropology and sociology have acquired the rank of distinct sciences. The study of institutions has reached a sudden development under the hands of Spencer, Tylor, McLennan, Maine, Freeman, Lang, and Bagehot. Comparative mythology and folk-lore have asserted their right to a full hearing. Evolutionism has penetrated all the studies which bear upon the divisions of human life. Language, ethnography, history, law, ethics, and politics, have all felt the widening wave of its influence. The idea of development and affiliation has been applied to speech, to writing, to arts, to literature, nay, even to such a detail as numismatics. Our entire view of man and his nature has been reversed, and a totally fresh meaning has been given to the study of savage manners, arts, and ideas, as well as to the results of antiquarian and archæological inquiry.

In psychology, the evolutionary impulse has mainly manifested itself in Herbert Spencer, and to a less degree in Bain, Sully, Romanes, Croom Robertson, and others of their school. The development of mind in man and animal has been traced *pari passu* with the development of the material organism. Instinct has been clearly separated from reason: the working of intelligence and of moral feeling has been recognized in horse and dog, in elephant and parrot, in bee and ant, in snail and spider. The genesis and differentiation of nervous systems have been fully worked out. Here Maudsley has carried the practical implications of the new psychology into the domain of mental pathology, and Ferrier has thrown a first ray of light upon the specific functions of portions of the brain. Galton's "Hereditary Genius" and other works have also profoundly influenced the thought of the epoch: while Bastian, Clifford, Jevons, and others have carried the same impulse with marked success into allied lines of psychological research.

But the evolutionary movement as a whole sums itself up most fully of all in the person and writings of Herbert Spencer, whose active life almost exactly covers and coincides with our half-century. It is to him that we owe the word evolution itself, and the general concept of evolution as a single, all-pervading natural process. He, too, has traced it out alone through all its modes, from sun and star, to plant and animal and human product. In his "First Principles," he has developed the system in its widest and most abstract general aspects; in the "Principles of Biology," he has applied it to organic life; in the "Principles of Psychology," to mind and habit; in the "Principles of Sociology," to societies, to politics, to religion, and to human activities and products generally. In Spencer, evolutionism finds its personal avatar: he has been at once its prophet, its priest, its architect, and its builder.

Second only in importance to the evolutionary movement among the scientific advances of our own day must be reckoned the establish-

ment of that profound fundamental physical principle, the conservation of energy. Even before the beginning of our half-century, Davy and Rumford (especially the latter) had caught faint glimpses of the coming truth in this direction. They recognized that heat was a mode of motion, and Rumford went so far as to observe that the energy generated by a given amount of hay burned in an engine might be measured against the energy generated by the same amount of hay consumed by horses. But to Dr. Joule, of Manchester, in our own time, is due the first great onward movement, in the discovery and determination of the mechanical equivalent of heat. Joule's numerous experiments on the exact relation between heat and mechanical energy resulted in the establishment of a formula of equivalence in terms of kilogrammetres necessary to raise by one degree centigrade the temperature of one kilogramme of water. More properly put, he showed that the energy required to raise a weight of one hundred pounds through one foot was equivalent to the amount required to raise a certain fixed quantity of water through one degree in temperature.

Starting from this settled point, it soon became clear to physical thinkers that every species of energy was more or less readily convertible into every other, and that an exact numerical equivalence existed between them. This principle, which first clearly emerged into the consciousness of physicists about the middle decades of the present century, was originally known under the name of "Persistence of Force," in which form Grove's well-known little treatise helped largely to popularize its acceptance. But, as time went on, the underlying distinction between force and energy came to be more definitely realized, and the phrase conservation of energy began to supersede the older and erroneous terminology. The realization of the varying nature of energy as potential and kinetic helped in the transformation of the prime concept. At last, under the hands of Clausius, Helmholtz, Mayer, Clerk Maxwell, Tait, and Balfour Stewart, the doctrine assumed its modern form—that all energies are mutually convertible, and that the sum-total of energy, potential and kinetic, is a constant quantity throughout the cosmos.

The practical applications of the doctrine of energy are as yet only in their infancy. The whole mass of theoretical science has to be re-written in accordance with this new and fundamental law. The whole field of applied science has to be developed and enlarged by the light of this pregnant and universal principle. Its implications are all-pervading. In astronomy it has profoundly affected all our conceptions as to the sun's heat, the orbits of planets, the nature of meteors, the past, present, and future of the universe. In biology it has taught us to envisage the plant mainly as a machine in which kinetic energy is being transformed into potential; the animal mainly as a machine in which potential energy is being transformed back again into kinetic. In mechanics and the mechanical arts it has produced

and is producing immense changes. And in the future it is destined still more profoundly to alter our mechanical ideas and activities: the great revolution there is only just beginning; another half-century is yet needed fully to develop it.

These two great principles—evolution and the conservation of energy—form the main bulk of our age's addition to the world's accumulated stock of knowledge. But among the separate sciences many wonderful advances have also been made which can not be overlooked in the briefest retrospect of the half-century's gains. To these a few words must next be devoted.

Among sciences of the abstract-concrete group, electricity had hardly got beyond the stage of an elegant amusement at the opening of our epoch. Statical electricity was still the department about which most was known. Galvanism as yet stood apart as a distinct study. Its connection with magnetism had not long been proved by the discoveries of Oersted. In 1837 itself, however, Wheatstone constructed the first telegraph. From that moment, under the fostering care of Faraday, Daniell, Cooke, Morse, Arago, Tyndall, Edison, and Thomson, electric science became a power in the world. The whole theory of electricity as a mode of energy has since been fully explored and expounded. A vast field has been added to science. Units and modes of absolute measurement have been invented. The telephone and microphone have been introduced; secondary batteries have been formed and improved; the dynamo has become a common object of the country; and the electric light has grown under our very eyes into a practical and extremely dazzling reality. Electricity, as we know it, with all its manifold useful applications, is almost entirely a creation of the last half-century.

In physics the present epoch, though chiefly remarkable for the series of investigations which led up to the discovery of the law of conservation, has also illustrated many minor principles of the first importance. The true theory of heat and the laws of radiant energy have been definitely formulated. The undulatory theory of light—a discovery of the previous quarter-century—has been universally adopted and justified. Thermo-dynamics have been elevated into a great and increasing branch of science. Sir William Thomson's law of dissipation of energy has completed and rounded off the theory of conservation. The causes and methods of glacier-motion have been investigated and established. Photography has almost passed through its entire life-cycle. The polarization of light has been observed and studied. Spectrum analysis has come into the front rank as an instrument of research. In short, a greater number of new physical phenomena have been discovered or old ones interpreted than in the whole space of previous time put together.

In chemistry, the advance has been more in detail than elsewhere. Chemical science alone still remains a somewhat fragmentary mass

of individual facts and observations, colligated by minor laws and analogies, but unilluminated as yet by the broad light of any great and all-embracing general principles. Since Dalton's atomic theory, indeed, no philosophic generalization of the very first magnitude has been introduced into chemistry. But generalizations of the second order—vastly interesting to chemists, and to chemists alone—have been made in such numbers as to defy enumeration; wider conceptions have in many ways sprung up; the science has assumed a new form; and some of the results of spectrum analysis and of the new chemistry lead to the hope that this science too is on the eve of arriving at that stage of far-reaching fundamental truths, which it is the special function of our generation to bring about.

Mathematics has also undergone a new development, scarcely capable of being rendered comprehensible to the lay intelligence.

The applications of physical, electrical, and chemical science in the great mechanical and industrial inventions of our iron age, belong elsewhere, and are already familiar in many respects to all of us. Railways slightly antedate the epoch; the telegraph is just coeval with it. The first submarine cable was in 1851, the first transatlantic in 1866. Electro-plating, the steam-hammer, the Armstrong gun, the Bessemer process, must not be forgotten. Other triumphs of applied science fall more fitly under another heading.

Among the concrete sciences, astronomy has made vast advances during the past half-century. Lord Rosse's great telescope was set up at Parsonstown in 1844. Two years later, Leverrier and Adams made their curious simultaneous discovery of the planet Neptune. But it is not so much in new lists of suns or satellites—though the name of these alone has, indeed, been legion—as in the fresh light cast upon the nature and constitution of older ones, that our age has been most singularly successful. The invention of the spectroscope, and the rapid development of spectrum analysis, have placed in the hands of astronomers a method and an instrument inferior in value only to the telescope itself. It is not so long since Comte dogmatically declared we could never know anything of the chemical composition of the fixed stars. Scarcely were the words well out of his mouth when the invention of the spectroscope and its application to the spectra of incandescent bodies brought the investigation of the elements in the sun and stars well within the reach of human possibility. The successive researches of Wheatstone, Foucault, Secchi, Bunsen, Kirchhoff, and Norman Lockyer, exactly covering our fifty years, have at last enabled us to prove almost with certainty the presence in the solar envelopes of several metals already known in the earth's crust, such as potassium, sodium, calcium, iron, nickel, and chromium. So delicate is the spectroscopic test, that it renders possible the detection of so small a fraction as $\frac{1}{100,000,000}$ part of a grain of sodium. And by revealing bright lines in the spectrum not

previously referable to any known body, it has been the means of discovering five new metals: cæsium and rubidium (detected by Bunsen), thallium (by Crookes), indium (by Richter), and gallium (by Lecoq).

Our knowledge of the sun's constitution, in particular, has advanced with extraordinary rapidity during the period here under review. Even thirty years ago we knew little of the central orb of our system save a few naked mathematical facts as to his diameter, his density, his attractive power, and the spots on his surface. Thirty years of constant investigation have now enabled us to picture to ourselves, with tolerable accuracy, the actual state of the sun's fiery exterior. The new era began with Schwabe's discovery of the periodicity of the sun's spots in 1851. The development of spectroscopic analysis between 1854 and 1870 followed hard on this first impulse. Since 1860 eclipses have yielded us valuable results. Observations on transits of Venus have largely corrected a serious error in our calculations of our primary's distance from the earth. Janssen and Lockyer have taught us how to observe at any time, by means of the spectroscope, phenomena which were previously observable only during moments of total eclipse. Huggins has shown us how to isolate those marvelous protuberances of incandescent gas which burst forth with explosive violence from time to time from the edge of the photosphere. Tacchini, Secchi, Young, and others have carried out these interesting researches to a still higher pitch of certainty and accuracy; and the sun's geography, so to speak, is to-day no longer a closed book to mundane observers. We know our central luminary now as a mass of intensely heated gas, surrounded by a shell of luminous cloud, the photosphere, formed by the cooling of condensable vapors at the surface where exposed to the cold of outer space; and floating in a chromosphere of incondensable gases (notably hydrogen) left behind by the formation of the photospheric clouds. The mysterious corona alone as yet evades our methods of research.

In the solar system at large, great advances have been made in the details of planetary astronomy. The differences in kind between the older group of interior planets, now in their cold and solid age, and the younger group of exterior planets, still in their boisterous and fiery youth, have been well ascertained. This truth—of so much interest from the evolutionary point of view—has been especially worked out by R. A. Proctor. Nasmyth's observations on our own dead satellite, the moon, have given us a graphic and appalling picture of a worn-out world in its last stage of lifeless, waterless, and airless decrepitude. New moons have been added to Mars, and several tedious additions have been made by minutely obstetrical astronomers to the already inconveniently large family of the minor planets. All our fresh knowledge of Jupiter and Saturn, those turbulent and volcanic orbs, has helped to impress the general soundness of the evolutionary hypothe-

sis; while the increasingly important study of meteors and comets has brought us close to the very threshold of the great ultimate mystery of star-genesis and world-forming. The extreme tenuity of the mass of comets, the inconceivable rarity of the matter composing their gaseous tails, the curious phenomena of the instantaneous reversal on passing their perihelion, the proof that their light is partly reflected and partly direct, the spectroscopic determination of their composition, the discovery of the essentially planetary nature of meteor-streams, and the recognition of their vast numbers swarming through space, are among the most striking novelties of the last half-century in this direction.

In sidereal astronomy, besides the mere mechanical increase of mapping, the chief advances have been made in observations upon double stars, spectroscopic analysis of fixed stars and of nebulæ, and consequent proof of the fact that truly irresolvable nebulæ do really exist, the gaseous raw material of future stars and solar systems. It must be added that within the half-century the hypothetical ether has amply vindicated its novel claim to take its place as a mysterious entity side by side with matter and energy among the ultimate components of the objective universe.

In geology, the chief theoretical advances have been made by the recognition of the cosmical aspects of the earth's history; its relations to nebula, sun, and meteor; the importance of eccentricity and precession of the equinoxes, and the possible results of ancient changes in its rates of motion, tides, and so forth. Dynamical geology has made vast strides, especially in the investigation of volcanic phenomena, mountain-building, and the birth and growth of islands and continents. The science of earth-sculpture has been developed from the very beginning. Stratigraphical geology has been largely improved. And in paleontology an immense number of the most striking and interesting of fossil forms have been brought to light. Among them may be specially mentioned those which have proved of critical importance as evidences of the truth of organic evolution—the toothed birds of the Western American cretaceous deposits, the lizard-like bird or bird-like feathered lizard of the Solenhofen slates, Marsh's remarkable series of ancestral horses, Cope's beautiful reconstruction of the fossil progenitors of existing camels. Monkeys certainly, anthropoid apes clearly, man doubtfully, have been detected in the fossil state. India, Australia, Canada, the United States have been explored and surveyed, geologically and paleontologically; and the exploitation of the far West in particular has not only added immensely to our knowledge of life in past times, but has also revolutionized our conceptions as to the gradual growth and development of continental areas, and the occasional vast scale of volcanic phenomena. The permanence of all great continents and oceans is now a proved truth of geology. It has been re-enforced and extended from a totally different point of view by Al-

fred Russel Wallace, whose masterly works on the "Geographical Distribution of Animals," and on "Island Life," have immense geological as well as biological implications.

In pure biology, besides the grand advance implied in the establishment of the doctrine of descent with modification, and its subsidiary principles of survival of the fittest and sexual selection, profoundly important minor results have also been attained in many directions. Embryology in the hands of Von Baer and his successors, notably Kowalevsky and Balfour, has acquired prime importance as an instrument of geological research. Comparative osteology in the hands of Owen, Huxley, Gaudry, and Busk has given us new views of the relationships between vertebrate animals. The pedigree of fishes, amphibians, reptiles, birds, and mammals has been worked out with a considerable degree of fullness from the hints supplied us by the amphioxus, the ascidian larva, the facts of embryology, and the numerous recent discoveries of intermediate or arrested organisms, recent and extinct. Invertebrate zoölogy has been rescued from chaos and partially reduced to temporary and uncertain order. Botany, at once the dullest and the most alluring of all sciences, has been redeemed from the vicious circle of mere classificatory schemes, and vivified by the fresh and quickening breath of the evolutionary spirit. The new morphology has revolutionized our ideas of vegetal homologies; the new physiology has fastened all its attention on the adaptations of the plant to its natural environment. The fascinating study of the mutual relations between flower and insect in particular, set on foot before the dawn of our epoch by Christian Sprengel, but reintroduced to notice in recent times by Darwin's works on orchids and on cross-fertilization, has been followed out with ardor to marvelous results by Hermann Müller, Axel, Delpino, Hildebrand, Lubbock, Ogle, and others. Heer and Saporta have worked out in great detail the development of several fossil floras. Last of all, Herbert Spencer has cast the dry light of his great organizing and generalizing intelligence on the problems of heredity, genesis, variation, individuality, and the laws of multiplication. Fifty years ago biology was a mighty maze wholly without a plan. To-day the clew has been found to all its main avenues, and even the keys of its minor recesses are for the most part well within reach of the enlightened observer.

Even the actual gains in the number of new organisms added to our lists during the last half-century are in themselves astonishing; and, strange to say, the species that bear most closely upon the theory of organic evolution are almost all of them quite recent additions to our stock of knowledge. The gorilla appeared on the scene at the critical moment for the "Descent of Man." Just on the stroke when they were most needed, connecting links, both fossil and living, turned up in abundance between fish and amphibians, amphibians and reptiles, reptiles and birds, birds and mammals, and all of these together

in a perfect network of curious cross-relationships. Lizards that were almost crows, marsupials that were almost ostriches, insectivores that were almost bats, rodents that were almost monkeys, have come at the very nick of time to prove the truth of descent with modification. Among the most interesting of these strange coincidences are such episodes as the discovery in the rivers of Queensland of that strange lung-bearing and gill-breathing fish, the barramunda, only known before in the fossil form as a long-extinct species, but in whose anatomical structure Günther has discerned the missing link between the antique ganoid type of fishes on the one hand, and the mud-fish and salamandroid amphibians on the other.

In the practical applications of biological and physiological science to the wants and diseases of human life two at least deserve mention here. Anæsthetics are almost entirely a growth of our half-century: chloroform was first employed in operations by Simpson in 1847, and the use of other similar agents is still more recent. Again, the discovery that zymotic diseases in men and animals are due to the multiplication within the body of very minute organisms, known as microbes, bacteria, or bacilli, now promises to revolutionize medical science. Their connection with decomposition was still earlier detected. The names of Pasteur, Tyndall, and Koch are specially identified with researches into the nature of these tiny morbid organisms and the best means of preventing or neutralizing their attacks, either on living or dead matter.

In marvelous contrast to the fragmentary and disjunctive science of fifty years ago, modern science at the present day offers us the spectacle of a simple, unified, and comprehensible cosmos, consisting everywhere of the same prime elements, drawn together everywhere by the same great forces, animated everywhere by the same constant and indestructible energies, evolving everywhere along the same lines in accordance with the self-same underlying principles. It shows us the community of ultimate material in sun and star, in nebula and meteor, in earth and air and planet and comet. It shows us identical metals and gases in fiery photosphere and in electrically-heated matter in our own laboratories. It shows us atoms of hydrogen or of sodium pulsating rhythmically with like oscillations in star-cloud or sun-cloud, and in London or Berlin. It exhibits to our eyes or to our scientific imagination a picture of the universe as a single whole, a picture of its evolution as a continuous process—one type of matter diffused throughout space; one gravitative attraction binding it together firmly in all parts; one multiform energy quivering through its molecules or traversing its ether, in many disguises of light, and heat, and sound, and electricity. It unfolds for us in vague hints the past of the universe as a diffuse mass of homogeneous matter, rolling in upon its local centers by gravitative force, and yielding up its primitive energy of separation as light and heat to the ethereal medium.

It suggests to us this primitive energy of separation as the probable source of such light and heat in suns and stars as we now know them. It posits for us our own planet as an orb gathered in from the original cloud-mass, with outer surface cooled and corrugated, and with two great envelopes, atmospheric and oceanic, gaseous and liquid, still floating or precipitated around its denser core. It teaches us how the hard crust of the hot central mass has been uplifted here into elevated table-land or depressed there into hollow ocean-bed. By the aid of its newest instrument, meteorology, it lets us see how incident solar energy, raising clouds and causing rainfall, with its attendant phenomena of drainage and rivers, has carved and denuded the upheaved masses into infinite variety of hill and valley. It shows us how sediment, thus gathered by streams on the bed of the sea, is pushed up once more by volcanic power or lateral pressure into Alpine chains and massive continents, and how these in their turn have been worn down by the long-continued bombardment of aqueous or aërial action into mere stumps or relics of their primitive magnitude. It puts before us life as an ultimate result of solar energy falling on the watery and gaseous shell of such a solidified planet. It suggests to us how light, acting chemically on the leaves or fronds or cells of the green herb, stores up in them carbohydrates, rich in potential energy, which animals afterward use up as food, or man utilizes as coal in his grates and his locomotives. It exhibits to us the animal organism as essentially a food-engine in whose recesses solar energy, stored as potential by the plant, is once more let loose by slow combustion in the kinetic form as heat and motion. It enables us to regard the body as a machine in which stomach and lungs stand for furnace and boiler, the muscles for cylinder, piston, and wheels, and the nervous system for an automatic valve-gear. It traces for us from small beginnings the gradual growth of limb and organ, of flower, fruit, and seed, of sense and intellect. With the simple key of survival of the fittest it unlocks for us the secret of organic diversity and universal adaptation. It reconstructs for us from obscure half-hints the origin of man; the earliest stages of human history; the rise of speech, of arts, of societies, of religion. It unifies and organizes all our concepts of the whole consistent system of Nature, and sets before our eyes the comprehensive and glorious idea of a cosmos which is one and the same throughout, in sun and star and world and atom, in light and heat and life and mechanism, in herb and tree and man and animal, in body, soul, and spirit, mind and matter. Almost all that is most vital and essential in this conception of our illimitable dwelling-place, the last half-century has built up for us unaided.—*Fortnightly Review.*

THE METAL ART OF ANCIENT MEXICO.

By HENRY L. REYNOLDS, Jr.

OF the contemporary writers of the conquest of ancient Mexico there are but three who have told us that there were in that city not only objects of gold, silver, and copper, but also some of bronze and tin. They have, moreover, told us that some of these metals were most skillfully wrought, and that the designs fashioned therefrom were so marvelous and beautiful that even the European goldsmiths of those days could not excel them.

However true this may be, it should be remarked that there is neither in the museums of this country, Spain, nor Mexico a single representative relic of this advanced skill in metal-working. All the Mexican specimens of unquestionable pre-Columbian origin that we have are of pure copper, and are simply hammered into shape. There are a few of bronze, but these, as well as some of copper, can not be said to antedate the conquest.

M. Guillaume Dupaix, who was employed by the King of Spain in 1805 to explore Mexico in search of remains of Aztec art, is the first to tell us anything about Mexican metal relics. Though an endeavor is evident throughout his notes to strengthen the belief in the greatness of Aztec civilization, the only metal specimens that he describes are three of what he calls "red copper." His annotator, Lenoir, referring to these metal specimens, properly adds that "this red copper is native, whereas the yellow copper is the result of *an alloy which the Mexicans, it appears, did not use.*" *

The twelve Mexican axes collected by Dr. Palmer, Mr. Frederick Ober, Professor Agassiz, and Mr. L. H. Ayme, seven of which are in the Peabody Museum at Cambridge, and the two in the National Museum at Washington, are all of pure copper; and Professor F. W. Putnam, who had the privilege of examining the former, tells us that there is no doubt that they were all shaped by hammering. This is also true of those in the National Museum.

These axes are of but two types, and it is gratifying to see that they correspond to the two forms figured in the ancient paintings. We might, therefore, reasonably deduce from this the fact that those figured axes were of a like composition to these that survive, and also that they were wrought with the hammer. To further sustain this conclusion, Landa gives, in his "Cosas de Yucatan," a cut of a Yucatan axe which also corresponds in shape to those just mentioned. These, he says, "are made of a certain metal, and shaped by hammering the edge with stones." Now, upon the authority of Cogolludo,† we know that these hammered axes of Yucatan were made in Mexico, and

* "Antiquités Mexicaines," deuxième partie, Planche II.

† "Historia de Yucatan," lib. iv, cap. iii.

brought from that country to be exchanged for other merchandise, and that they were made of copper.

All those very uniform implements, termed "T-shaped," of which we know, are also of pure or unalloyed copper. As to these, however, there is nothing in the records or in the objects themselves to warrant belief in their ante-Cortesian origin. The material of which they are made appears to be the hammered sheet-copper in use before the invention of the rolling-mill in 1784, and which formed, as the records show, a very favorite article of aboriginal trade. The specimens bear no evidence of oxidation to indicate great age, and the fact that their edges are very neatly cut gives rise to the suspicion that their manufacture must have been subsequent to the introduction of the necessary European cutting-tools. They were found only in the State of Oaxaca, and in each find there were great numbers of them. It is not improbable, then, that for some purpose or other a large lot of sheet-copper was at an early day introduced among the natives of that section, who in turn converted it into these implements. What special use they were intended to serve we can at present only surmise. The absence of objects like these in the aboriginal codices should be noted, while throughout the whole literature of the conquest there is but one approach to their description. This is found in Torquemada, who says: "They also used certain copper coins almost in the shape of a Greek Tau, its width about three or four fingers. It was a thin piece of plate of an uncertain size, and contained much gold." It is not likely that the specimens in question were used as coins, for the edges of what might be called the shank are flattened as if for the attachment of a handle, and hence its probable use as an implement. Moreover, they do not answer to Torquemada's description, for, instead of being three or four fingers in width, they vary in this respect from fourteen to twenty centimetres; and, instead of containing much gold, analyses have proved them to be of very pure copper. Admitting them, however, to be the objects that Torquemada had in mind when he wrote, he is not sufficient authority for ascribing them to pre-Cortesian art.

In the National Museum at Washington there are three copper specimens that were used as awls. One of them, which is nine inches long, is pointed at one end, and flattened or beveled at the other, while it bears unmistakable evidences of having been shaped by hammering. It closely resembles in form, composition, and fabrication a similar tool lately procured by the Bureau of Ethnology from a mound in Wisconsin. These, with other specimens, were purchased from the collection of the distinguished Mexican archæologist, Don Fernando Ramirez, but it is to be deeply regretted that, with the exception of one or two specimens, no data accompanied them as to the locality or manner in which they were found. We can not even say with certainty that they were found within the limits of Mexico.

In this collection came also five specimens the precise use of which

we do not know. They also are of copper, but a close examination shows them to be unmistakably of drawn wire, the manufacture of which it is not pretended the pre-Columbian native knew. These specimens consist each of a single piece of wire, averaging four inches in length, and are flattened or beveled at both ends.

Besides the above specimens, this collection comprises two needles of copper, two objects of twisted copper wire, nine little bells, and two bronze chisels.

The two needles, like the specimens last described, are of drawn copper wire, and are so called because in one end there is an eye, while the other is slightly pointed.

The two twisted wire specimens consist of four pieces of very fine copper wire, six inches long, and neatly twisted about one another. The purpose they served is a matter of speculation.

Four of the little bells in this collection appear to be alloyed, but are we warranted, in the absence of knowledge as to where and how they were obtained, in ascribing them to pre-Cortesian art? They bear no evidences of oxidation to indicate great age, and I am disposed to regard them as the bells of which Sahagun speaks in the following quotation: "The goldsmith is an expert in the selection of good metal. He knows how to make of it whatever he likes, and does it with skill and elegance. He is conversant with all kinds of devices, and all this he does with composure and accuracy. He knows how to purify the ore and make plates of silver as well as of gold from the cast metal. He knows likewise how to make *molds of carbon*, and how to put the metal into the fire in order to smelt it." Farther on he says: "He who is a trader in needles casts, cleans, and polishes them well; he makes also bells, filters, punches, nails, axes, hatchets, coopers' adzes, and chisels."*

No one will pretend that Sahagun here refers to the metal-smiths as they worked before the conquest. For thirty years he lived among the surviving natives, to study their language and record all that he could concerning their customs, mythology, and arts. He gives, whenever it is obtained, all hearsay testimony as to the civilization which the Spaniards destroyed, but the bulk of his work, excepting the twelfth book, which is devoted to a history of the conquest, is the result of a study of the natives as he found them. This is evident in this case from the fact that he enumerates molds of carbon, needles, filters, coopers' adzes, hatchets, and nails, none of which are mentioned by the chroniclers of the conquest. Dr. Philipp Valentini, commenting upon this quotation, says, "A few new features are cropping out in this enumeration of implements, which give rise to the suspicion that the goldsmith is described, not as he worked before the year 1521, but as he had perfected himself and enlarged his technical knowledge through the intervention of Spanish mechanics in the year

* "Historia de la Nueva España," lib. x, cap. vii.

of Sahagun's writing, about 1550." These metal-smiths were evidently bound to secrecy in their art, for, in the Viceroy Mendoza's time, Lorenzana says that one of these workmen was imprisoned for counterfeiting the Spanish coins, and, though he was promised pardon if he would reveal the workshops of his people, his persistent silence caused him to be put to death.

We find that chisels also are enumerated by Sahagun in the above quotation, and there is no reason why we can not ascribe the three bronze chisels that we have to the native metal-smiths to whom he refers. We have, at any rate, no evidence, historic or archæologic, by which we might reasonably consider them as belonging to the period before the conquest. Two of these bronze chisels are in the National Museum at Washington, but, unfortunately for our present investigation, their origin is unknown, and no analysis of them has been made to determine the relative percentage of copper and tin.

The remaining bronze chisel is in the Museum of Mexico, and is described and figured in the annals of that institution, Vol. I, page 117. It should be noted that its form is very unlike either of the two to which we have above referred, and that it has a percentage of 97·87 parts of copper and 2·13 of tin, which is precisely the same as that of a bronze chisel found by Mr. J. H. Blake in Peru and described in Wilson's "Prehistoric Man," Vol. I, page 293. We know not where, when, or how it was found, and if we doubt that it was fashioned by the native metal-smiths who worked after the advent of the Spaniards, we might suppose it to have wandered thus far from its Peruvian home, for greater distances, we know, did the copper of Lake Superior travel in aboriginal barter.

But besides these there have also been found many other chisels, and these as far as we know are all of copper. Dupaix describes several which were plowed up in the neighborhood of the village of Antequera in Oaxaca. They are composed, he says, of red copper which we remember his editor, Lenoir, called native. Dr. Philipp Valentini refers to another which, he says, is similar in form and composition to those described by Dupaix. This was plowed up by Señor Andrez Axnar Perez on his plantation near the river Zompan in Tabasco, at a depth of nearly twelve inches. Unfortunately, none of Dupaix's chisels can now be found, but the cut he gives shows them to have been of the simplest form, and not unlike those in use by our carpenters to-day. These, and that of Señor Perez, are uniform in shape and composition, while each of the three of bronze presents a strikingly odd and distinct type. An analysis of their composition would doubtless show also a varying percentage of copper and tin, and we feel tempted, under the circumstances, to regard those of pure copper, which are uniform, as indigenous, and the bronze, which are odd, as importations from South America, or else the product of post-Columbian skill.

Thus we see that, excepting three chisels and four bronze bells, the specimens are all of pure copper, and, whether or not this pure copper is native, chemical experiments have not yet been able to determine. The fact that drawn wire is catalogued with the bronze specimens as Mexican antiquities bids us receive them with caution; and in this connection we must remember what Sahagun and Lorenzana have told us, that the Mexicans after the conquest, like the Navajos to-day, utilized some of the arts of the European, and worked largely and skillfully in metals. We must remember, also, that there has never been in Mexico, as in Peru and Wisconsin, a discovery of an ancient mine, neither a crucible nor any kind of tool by which the metal was extracted from the ore, yet investigations have been going on very actively in Mexico for nearly a century and a half.

We have, then, nothing whatever, so far as archæologic evidence goes, to show that the Mexicans acquired and practiced the art of smelting, refining, and alloying before the advent of the Spaniard.

Turning from this fact to an examination of the early historic records, we learn that Cortes, Gomora, and Bernal Diaz are the only original authorities whose statements imply a knowledge of smelting. But the honesty and accuracy of these very writers have been questioned. Though founded, to be sure, upon a more or less substantial basis of fact, their descriptions of Mexican civilization are palpably colored and idealized. The natural features of the country refute many of their statements, while others are characterized by gross discrepancy. They have been regarded, therefore, for the most part, as imaginary and delusive, and, since they are the main basis upon which rests the popular idea of a high civilization in ancient Mexico, that civilization has been thought fictitious in some of its most essential features, and in general greatly overdrawn.

Examining first the accounts of the expeditions that touched upon the shores of Yucatan and Central America prior to 1519, we find no mention of any metals except pure copper and gold. But Cortes, on the other hand, in one of his letters to the emperor, says that he saw within the market-place of Mexico "trinkets of gold and silver, of lead, bronze, copper, and tin." I can not agree with many writers in thinking that the gold which Cortes saw was the product of so enlightened and difficult an art as smelting. Though gold in the ore is rich and plentiful in the Mexican country, the inhabitants could not have been aware of any better method of obtaining it than by sifting it from river sands. Notwithstanding his numerous observations of marvelously wrought gold objects in Mexico, Bernal Diaz's own words should establish this fact. Montezuma, he says, informed them that their gold "was obtained from the province of Zacatula, where the earth which contained it was washed in wooden vessels, and the gold-dust sank to the bottom." It was also to be had, he says, in Tustepec, "where it was collected from the beds of rivers." Again,

speaking of the expeditions sent out by Cortes in search of mines, he says that Gonzalo de Umbria, who went to Zacatula, reported that there "the natives washed gold out of the sand in small troughs."

If this were the only means employed, it is improbable that the Spaniards saw it in all the instances and in the great quantity that Cortez and Bernal Diaz describe; and that their statements in this regard are grossly exaggerated is evident from the fact that, with the exception of a few small trinkets, not a relic of the beautiful things of which they speak remains. Neither do the chronicles record a very great amount actually gathered by the rapacious conqueror, yet all the schemes which his mind could conceive must have been directed to this one object, not for personal greed only, but to meet the expectations of the emperor, to whom, when he had feared that he was to be deprived of his command, he had promised wealth and treasure. Though torture of the most barbaric description was employed to induce the natives to reveal the riches that they were supposed to hide, no more were obtained; and, in order that the Spanish king and those about his court may afterward understand the absence of the treasure in the kind and quantity which he had led them to expect, Cortes cautiously wrote that it was all lost in that disastrous revolution which first drove him from the city.

It is not to be supposed either that the half-civilized Aztec was aware of those many complex chemical processes by which silver is separated from the ore. If we are to credit him with this, we must call him a great metallurgist indeed, skilled in an art known even now only to a few, and which demands all the machinery and scientific accomplishments of our modern times. We know to-day that Mexico is richer in silver than any other country in the world, yet the mention of this metal in the records is noticeably infrequent, and it is especially significant that it does not figure in the articles of tribute. Let us, nevertheless, believe the exaggerating Gomora, and we find that all the silver actually collected by the Spaniards was only five hundred marks. These facts can not be reconciled with a knowledge of smelting. The little silver they may have had was doubtless only the native metal which is to be found in Mexico, or that which was obtained like the gold from the placer-washings.

Bronze, too, is in Cortes's list of metals, and if we accept bronze we must also accept tin, its necessary component. Though Cortes tells us that he saw tin in the market-place of Mexico, we find him shortly afterward deploring its absence when he desires to cast some cannon. He does not ask the natives to show him whence the tin of the market-place was obtained, but sends only his own men "*searching in all directions*," until it was at last found in the form of coins among the natives of Tasco. Then, inconsistent with his past conduct, he does not rob the natives of this very coveted metal, though his "distress for it had reached its highest point," but he sends his Span-

iards, unassisted by natives, "*with the necessary tools* to bring him samples of it." After this a sufficient quantity is procured, though it cost him, he says, "*a work of much labor.*"

But, however much this may indicate the possession of tin among the natives, we know to-day that there is none in Tasco; and though, perhaps, it may be found in Michoacan and Jalisco, the Mexicans have not thought it worth their while to work it. Baron Humboldt, who paid a visit to Tasco, had perhaps the best opportunities for the discovery of a mine, but nowhere does he speak of finding any traces of such ancient works. Though he must have known what Cortes had said concerning Tasco, he tells us that there the natives obtained not tin, but silver. This tin of Tasco, it should be noted, is not mentioned by Bernal Diaz or Gomora, and this, with the tin seen on sale in the Mexican market, both vague and barren of description as to how it was obtained, are the only instances in the authorities upon which our belief is based. Tin, strange to say, is not embraced in that well-known list of tributes which were paid to Montezuma by the subordinate tribes, neither can it claim the distinction accorded to copper and gold to be figured in the ancient paintings. The axes figured therein, we have heretofore seen, could scarcely have been an alloy of copper and tin, for their shape corresponds to the axes in our museums, which are of hammered pure copper.

Our belief, then, in what Cortes has said concerning this metal is somewhat shaken, but additional reason for discrediting him will be hereinafter presented when we come to consider the circumstances that influenced his statements.

The fact that lead is also enumerated is enough to warn us to take these statements *cum grano salis.* I know of no place in Mexico where lead is worked to-day, though Humboldt tells us that in 1803 it was feebly mined in the extreme northeast. It is found to a limited extent in the States of Oaxaca and Chihuahua, but it is associated with silver; and, if the natives made use of this supply, which is extremely doubtful, they must have possessed the scientific knowledge by means of which the two metals are separated. Cortes is sustained in this statement as to lead only by Gomora; and he, while designedly reasserting what his master and patron had already said about the metals of the market-place, is careful, however, to add the important qualification that "lead was scarce."

The subordinate Cortes, on landing in Mexico, shrewdly saw in its conquest an opportunity for his ambition. He feared that he might in this be superseded by another should he await the forms of Spanish law, so he contrived an election by which he was irregularly made a captain-general, and then boldly undertook a military expedition without a royal charter.

Thus there is hardly a doubt, and his letters plainly indicate it, that his prime object in these reports was to so frame them as to se-

cure imperial pardon for his offenses, as well as sanction to continue the conquest. Therefore, he pictured the El Dorado of which Spaniards were wont to dream, whose wealth would fill the emperor's depleted treasury, and whose greatness would augment the power of his realm. All that he saw and did was extravagantly colored in such language and terminology as would magnify his adventures, and at the same time picture the conquest of a country after the Spanish ideal. Besides this, he tells how the people were idolaters and human sacrificers; how he overturned their false idols and set up crosses and images of the Virgin in their stead; and how, by constant appeals to them to embrace the religion of the Spaniards, it pleased God to make him the means of converting many. Thus, by emphasizing his acts as religious, and giving his expedition the color of a holy war, did he also secure the necessary and powerful influence of the priests at court, who, in those days of a jealous Inquisition, the Romish sovereign dare not ignore.

These letters were dispatched by trusted messengers direct to his Majesty in Spain, and, that their object might be the more surely accomplished, a quantity of virgin gold was sent with one of them, which was either gathered from the Mexicans themselves or by the Spaniards with native aid.

These considerations should influence our judgment as to the truth of Cortes's Aztec story. Even Mr. Hubert Bancroft says that "he was ever ready with a lie when it suited his purpose," and that he sees in his letters "calculated misstatements both direct and negative." Dr. Robertson, too, though he accepts them as so much history, is forced to confess that such and such a statement "seems improbable."

Besides Cortes, however, both Gomora and Bernal Diaz speak of bronze and tin, but it is only in the single instance when the merchandise of the market-place is described. Gomora only enumerates the metals, without describing the form in which they were used, and Bernal Diaz's words are, "They had for sale bronze axes, copper, and tin."

But Gomora, it should be remembered, was Cortes's secretary and chaplain, and, as Dr. Robertson says, he probably composed his work at his master's dictation, we naturally expect him to repeat the latter's highly-colored and delusive account of Aztec art. If he obtained versions from other lips besides his master's, it was all doubtless recorded in the manner the latter desired. Indeed, Las Casas asserts this most positively, and in another place adds also the charge of "downright falsehood." Muñoz and Robertson have rejected him as a reliable authority, and even his contemporary, Bernal Diaz, has emphatically accused him of adulation and inaccuracy.

But Bernal Diaz himself can not be believed, and in him we have the last of the three authorities for aboriginal smelting. A reading of his work alone would lead the educated mind of to-day to doubt the

best part of what he describes. Though he denounces the figures of Gomora as eight times too large, his own remain plainly extravagant: for instance, the number and population of the valley cities which he gives would be more than the natural conditions of the country could support. One hundred and thirty-eight years after the conquest Thomas Gage confessed himself sorely puzzled to account for the disappearance of these cities as described; and Mr. Lewis H. Morgan, in his "Houses and House-Life of the Aborigines," even rejects the idea of their actual existence. Mr. Morgan, I might say, discredits these three authors in nearly everything except the main acts of the Spaniards, and these, he says, are all that can be accepted as historical, while "the descriptions of Indian society and government are imaginary and delusive."

I was glad to see that Mr. David A. Wells, in the April, 1886, number of this magazine, took the same view. He says that the popular idea of the civilization of ancient Mexico has very little foundation, and the fascinating narrations of Prescott as well as the Spanish chronicles from which he drew his so-called historic data, are little other than the merest romance, not much more worthy, in fact, of respect and credence than the equally fascinating stories of 'Sindbad the Sailor.' And in defense of this conclusion he calls attention, among other things, to the fact that the relics in the Museum of Mexico, which are probably the best collection of the remains of the so-called Aztec people that ever has been gathered, are very little better than those from the Western mounds and some of the Indian tribes of the United States.

Though it is a harder task to impeach the motives and work of Bernal Diaz than those of Cortes and Gomora, we must nevertheless consider that his original manuscript slumbered unpublished in private hands for fifty years after his death, and then was printed for the first time in Spain under a censorship decree by Alonzo Remon, a Franciscan priest. Brasseur de Bourbourg says he saw the original manuscript in Guatemala; and Scherzer, who also saw it there, informs us that the text, as published, is very incorrect. Moreover, in Rivadeneyra's "Historiadores Primitivos de Indias," tom. ii, we find that the above edition of Padre Remon, first appeared in 1675 in Guatemala, although it was printed in 1632! Thereupon, Señor Fuentes, a descendant of Bernal Diaz, said that "it contained in some parts more and in others less than my great-grandfather wrote." He added, also, that the title on the original cover, which the family have preserved and kept in sight, is simply "Ancianidad Manuscrito," and not "Historia Verdadera de la Conquista de la Nueva España, por el Capitan Bernal Diaz del Castilo, un de los Conquistadores." We learn also from the above authority that the inaccuracy commences at the very beginning of the narrative, for the opening words are not those given in the printed edition.

Thus there is scarcely a doubt that, in the process of copying, changes greater or less were made; and, since the work had to receive the sanction of the Inquisition, it is not unlikely that it was changed to conform, in certain necessary and possible features, to the records already licensed which emphasized the conquest as a triumph of the Church. It is not unlikely, also, that by this time a better knowledge of the conquered land and people had led many to doubt much that Cortes and Gomora had described, and, though dead fifty years, Bernal Diaz was thus brought forward as a convenient corroborative authority.

In this connection it is not a little significant that Bernal Diaz is an extremely zealous churchman, and that the expressions which he, an unlearned soldier, uses, correspond almost precisely to those which characterize the writings of the priests of that period. His narrative is filled throughout with religious observations and considerable emphasis is given to acts done in aid of the Church.

Moreover, we notice that he resents the imputations of Las Casas of inhumanity and inaccuracy. This is especially noteworthy when we consider that while at Guatemala in 1560 he could not have known what Las Casas had written, for the latter's "Historia General" was not completed when that author died in 1561, and then his injunction that no one should use it for forty years after his death must have been strictly obeyed.

But whether the Remon edition of Bernal Diaz be a true copy or not, we can not at any rate reconcile our knowledge of Mexican topography and resources with much that he therein relates; and as for his elaborate particulars of Mexican art and civilization, they are so plainly idealistic that our common sense forbids us to believe them. Even Mr. Prescott contends that "the more intimate our acquaintance with his narrative the less is our confidence in the accuracy of his details."

Besides Cortes and Bernal Diaz, however, there are two other authorities who were eye-witnesses of Mexican art before the conquest. These were the so-called Anonymous Conqueror and Andres de Tapia. Both were Cortes's captains, and both have left personal accounts of what they saw, which Icazbalceta has recently taken from their obscurity and published in his "Coleccion de Documentos para la Historia de Mexico." The Anonymous Conqueror gives a full description of Mexico, its country, resources, people, and customs, but, in his detailed account of the Mexican market-place, its separate stalls and the various articles on sale therein, there is no mention of any metal except gold. Mr. Hubert Bancroft has properly said of this writer that "his method and language denote intelligence and inspire confidence. Dealing wholly with native institutions he seems to have no desire as is the case with some to magnify native strength and resources for the sake of raising the estimate of the deeds of himself and comrades.

His whole narrative bears the stamp of reliability, and the student may easily from internal evidence and comparison deduct approximate truth."

Andres de Tapia, on the other hand, describes the march against Mexico as well as all that was seen and done upon its entry, and although apparently a panegyrist of the conqueror, he is absolutely silent concerning the elaborate silver presents which he is said to have received. Neither does he testify to the bronze, lead, and tin of the Mexican market. Our confidence in Cortes and Bernal Diaz, the other two eye-witnesses, being impaired, these facts should be given no little significance. There is one instance, however, in which Tapia mentions silver, and in this he says that "Montezuma's treasures of gold, silver, and greenstones, of not very fine quality, were shown to himself and another Spaniard in the Casa de las Aves," or the House of the Birds.

Another contemporary writer who is of unquestionable authority is Bernadino de Sahagun. He was a Franciscan priest, and came to Mexico eight years after the conquest. He studied the native tongue, and became more proficient in it than any other Spaniard. He studied also the motives, lives, and thoughts of the natives and got from them their hieroglyphics which he expressed in the Roman character. His work is composed from the evidence in large part of Aztec eye-witnesses, and these are mingled, though somewhat confusedly, with recollections from old Spanish soldiers. He gives considerable space to the arts of the natives and their manner of work, and though he speaks of their work in gold, and this as performed with the hammer, he fails to furnish any information in regard to silver, bronze, and tin. Now, if the ancient Mexicans separated tin from its ore and knew how to fuse it with copper to make bronze, it must certainly be considered strange that Sahagun so soon after the conquest neither saw a relic thereof, nor obtained from the surviving Aztecs any account of their skill in this regard. Sahagun, moreover, in his twelfth book, gives a full description of the conquest. Herein he describes in detail the presents of gold, feathers, etc., which Montezuma made at different times to Cortes, but he is careful to omit all mention of any of silver. Not a word about that wonderful silver disk that represented the moon, neither any mention of what we deem still more wonderful, namely, that lead, tin, and bronze were seen on sale in the market-place of the conquered city. He would indeed be remiss in his duty as an historian should he omit all mention of a feature so singular and important were he confident that it was true. All that he has to narrate, concerning the metals that the Spaniards saw in Mexico, is that Montezuma showed them a hall where were stored bright feathers, "and many rich trinkets of plumes, gold, and stones," and then when the Spaniards expressed their desire to see the contents of his private chamber, which was called "Totocalco," or the House of the Birds,

they saw therein "many trinkets of gold and silver, all of which they took away."

These facts demand particular attention when it is known that this account of the expedition was composed upon the evidence of surviving natives, and the recollections of disinterested soldiers.

We desire to refer in this connection to the fact that Sahagun's vague and only mention of silver, namely, that it was seen with gold, feathers, and stones in Montezuma's private chamber, called Totocalco, or the House of the Birds, is also the only one of which the eye-witness Tapia speaks. The latter frankly says that "trinkets of gold, silver, and greenstones of not very fine quality, were shown to himself and another Spaniard in the House of the Birds" (Casa de las Aves).

These two sober accounts can not be impeached. They are the testimony of eye-witnesses who had no thoughts of how their stories could secure the censor's license. The one innocently confirms the other, and we are forced to accept them as giving us an honest, truthful picture of just what metals the Spaniards actually saw.

Thus we have presented everything upon which the historic view of our subject can properly and authoritatively rest. We can not, however, conscientiously believe the best part of the somewhat idealized stories of Cortes and Bernal Diaz, for we have seen how Cortes's letters were influenced by his ambition, and why the printed edition of Diaz can not be accepted as a *verbatim* copy of his original manuscript. Besides this, not only do the natural conditions of the country refute many of their statements, but, strange to say, nowhere in all our archæologic archives is there to be found a single relic of the wealth and elaborate conveniences that they describe. We accordingly feel warranted in discrediting this much of what they say, namely, that Diaz once saw for sale "axes of bronze," and Cortes "trinkets of lead, bronze, and tin," in Mexico, and tin coins among the natives of Tasco.

A careful examination, both of the ancient pictures and the early chronicles, does not develop the fact that copper, much less bronze, was ever employed by the natives in implements of war. Scarcely anything either is said concerning metal tools. Diaz is the only man who is said to have seen some, and these were axes only, but neither he nor any one else saw one in actual use. These facts can not be reconciled with the idea that they worked so extensively as to have, as Baron Humboldt says, galleries and shafts, and that they smelted the ore, and alloyed the refined metal to make bronze.

We are not surprised when the records tell us of so much gold, nor even of silver in Mexico, but we would be if they contained anything that spoke of an extensive use of copper, for we know that native copper in Mexico is found only in a very limited degree. This native copper, with perhaps some that came from Lake Superior, through an extensive traffic, was doubtless all that they possessed.

It may be asked, however, how came their temples, and such works as the so-called Calendar Stone, for instance, so exquisitely carved, if they knew not the use of bronze? As for their temples, Mr. Norman has told us that most of them are composed of a fine concrete limestone, in the carving of which "flint was undoubtedly used." Only implements of flint, obsidian, and other stones, and copper have been found among these ruins, and this fact rather encourages the belief that the natives carved these stones when first taken from the quarry, in their soft condition, with tools of this description, the rock afterward becoming hard on exposure to the air. Herrera, speaking of the districts of Yucatan, distinctly tells us that "in all of them there were so many and such stately stone buildings, that it was amazing, and the greatest wonder is that, having no use of any metal, they were able to raise such structures." Landa, too, who was a contemporary of the conquest, adds his testimony by saying that "there exist many beautiful structures of masonry in Yucatan, all of them built of stone, and showing the finest workmanship, *the most astonishing that ever were discovered in the Indies*, and we can not wonder at it enough, because there is not any class of metal in this country by which such works could be accomplished."

The so-called Calendar and Sacrificial Stones unearthed in the city of Mexico, and most of their idols, are made from large blocks of basalt, and to dress or carve this very hard volcanic material with a bronze chisel, however well it may be tempered, is impossible. A process of grinding and rubbing, which archæologists have now demonstrated to be extremely practicable, and in which the Mexicans, as in other things, became more expert than their northern brethren, was doubtless the only means employed.

The remains of native work in bas relief are now known to be very numerous, but neither among the ruins of Palenque, Uxmal, Copan, Chichen, nor Mitla can there be found a single metal tool. Had these extensive works been fashioned with bronze implements, far more specimens than the paltry three that we have would have come to light ere now, within the broad area in which they are embraced.

PRESIDENT BARNARD reviews the subject of elective studies in his annual report of Columbia College. He thinks that during the growing period of the mind the studies should be prescribed, for discipline, and to discover the bent of the mind. They should, at the same time, be so varied as to offer every faculty of the mind an equal inducement for exertion. The preference will then be free to manifest itself. The time for introducing the elective element should be fixed, then, rather with reference to maturity of years than to the degree of advancement in the four years' round of college study. This, with the average of college students, appears to be attained in the nineteenth or twentieth year; an age which corresponds, in most students, nearly with the end of the sophomore year.

CHANGES IN THE ASPECT OF MARS.

By STANISLAUS MEUNIER.

THE planet Mars has for a long time signalized itself to observers by the remarkable traits of its constitution. In consequence of its relative nearness, the telescope has been able to furnish us with a number of data respecting its physical geography and its meteorology; and it has been a very rich source of results concerning the philosophy of the solar system and the physical universe in general.

It is well known that Mars displays some bright spots, and others dark, of which we have every reason to consider the former to be continents, the latter seas. Toward the poles appear large white zones, varying in size at different times, which are caps of ice, susceptible of occasional breakings-up like our icebergs. In the thin and transparent atmosphere we can distinguish clouds, currents, and sometimes whirlwinds quite like the cyclones that rage among us.

Besides these intimate analogies with the earth, the study of Mars reveals especial features, some of which are most satisfactorily explained by considerations of comparative geology. With the tenuity of the atmosphere is associated a much smaller extension of the seas, and the relative repartition of land and water is very different from what prevails on the earth. Astronomers observe, as one of the most remarkable peculiarities of the surface of this planetary neighbor of ours, a large number of long and narrow passages and seas like bottlenecks. In our globe the oceans are of three times the surface of the continents; and Europe, Asia, and Africa form together a single island, while another island is formed by the union of the two Americas. But, on Mars, an almost complete equality exists between the surfaces occupied by the continents and by the seas. Further, they are mingled with one another in such a complicated manner that a traveler might visit nearly all the quarters of the planet, either by land or by boat, without having to leave the element on which he began his journey.

This much assumed, it should be recollected that Mars is older in the planetary series than the earth; that is, having been individualized at a more ancient period, and having a smaller volume, it has reached a more advanced stage in the sidereal evolution. Hence the planet represents now, in its great lines and independent of its individual characteristics, a condition which the earth will ultimately attain. One of the effects of the secular cooling of the earth is to determine the progressive absorption of the waters of the ocean by the successively consolidated rocky masses. Hence a striking comparison might be made between the present Martial seas and the terrestrial oceans after we shall have supposed they have been in a more or less great part absorbed. The results of innumerable soundings have permitted the

construction of bathymetric charts of our oceans; and thirteen years ago I described the form of the Atlantic Ocean at four thousand metres below the present surface as "bottle-necked." If, then, we suppose the water of the Atlantic to become absorbed in the profound masses at this moment in process of solidification, in such a way that the level of that ocean shall be depressed by four thousand metres, we shall have at the same time a much smaller surface covered by water, and a narrow and elongated form of the seas, or exactly the conditions which Mars presents. At the same time that the water is thus drunken up, the air also will be undergoing absorption. All the rocks are aërated. We know what trouble we have in driving the air from even the most compact rock of which we wish to obtain the density with precision. Since the different mineral masses become aërated while they are becoming moist, and consequently, while they are cooling, the atmospheric strata should undergo a progressive decrease. It is, therefore, natural that the atmosphere of Mars should be much thinner than that of the earth; and that is an excellent condition for the telescopic study of the planet.

For the earth, geology furnishes a kind of indirect confirmation of this progressing absorption of the atmosphere. The results of the experiments of physicists, of Mr. Tyndall in particular, go to show that a slight augmentation in the thickness of our atmosphere or in the proportion of vapor it contains, would suffice to cause the solar heat to be stored in larger quantity and wasted more slowly; that is, in short, would make what we call climates disappear—a warm and nearly equable temperature prevailing over all the earth. Now, one of the most remarkable characteristics of the ancient geological periods is just this absence of climate, which is indicated by the uniformity of fauna and flora over the whole planet; and this confirms our opinion that the atmosphere once formed a much thicker bed than it does now.

While there thus exist traits in common between Mars and the earth, a strange motive of interest lies in the existence on the surface of the former globe of very important details of structure which are without analogy with us. M. Schiaparelli first perceived, in 1877, in the continents of Mars, which had been till then very large and without solution of continuity, a system of dark channels, often very slender, which divided the surface into a multitude of lands isolated and separated from one another like the meshes of a net. Notwithstanding the tenuity of these channels, they are not less than one hundred and twenty kilometres in breadth, while some of them are fully forty-eight hundred kilometres long. These results were at first received with incredulity by astronomers, who were afterward, however, constrained to recognize their rigorous exactness. The works of the distinguished director of the observatory at Milan upon this subject, of which the last one, relative to the opposition of 1879–'80, constitutes a

quarto memoir of one hundred and nine pages and six plates, are very interesting.

But it is since this magnificent publication appeared that the author, on the occasion of the opposition of Mars of 1881–'82, was a witness of some marvelous changes which are fully described in a memoir that has not yet appeared, but which M. Schiaparelli has kindly sent me. It appears from these observations, and from others which were made between 1884 and 1886, that Mars is at this moment the theatre of phenomena of stupendous grandeur which will be adequate in a few years to impress profound changes in its aspect. The views taken by M. Schiaparelli show that a number of the channels previously described are doubling, or are being paralleled by similar ones having the same dimensions and directions. The appearance on the new map of the hemisphere is nearly the same, Dr. Terby, an eminent areographer, of Louvain, suggests, as would be produced in the former one by covering it with a double-refracting crystal. To this phenomenon, which has no analogy, M. Schiaparelli has given the name of the gemination of canals; and he has prepared a full memoir respecting it, which will shortly appear.

Although they were met at first with incredulity, these astonishing discoveries have received and are receiving constant confirmation from the observations of such men as Boeddicker and Burton in Ireland, M. Perrotin of the observatory at Nice, and his collaborators, MM. Trepied, Thollon, and Gautier. Other observers, like Messrs. Green, Knobel, and Denning, have not been so fortunate in verifying his facts, but their researches, published in the memoirs of the London Astronomical Society, and in the "Monthly Notices," are full of interest. It adds to the mystery that the gemination seems to be made gradually, though rapidly, and with progressive accentuation. Thus, the canal Nilus, at the junction of the eightieth meridian and parallel 20° north, is paralleled by another canal, which is very faintly marked and hardly visible in the older map. In the new map the two canals have a nearly equal intensity.

By careful comparison of Schroeter's designs, made a century ago, and Herschel's earlier ones, M. Terby has discovered analogous modifications on the Martial surface. Some of them are local enlargements of some of the seas, like that called Kaiser, and other changes in the details of configurations which had been supposed to be fixed. Of similar character is the memoir of M. Van de Sand Baghuyzen, in the "Annals of the Observatory of Leyden," in which the author interprets the designs of Schroeter and finds in them a trace of many of M. Schiaparelli's details. Père Lamey has also made many observations of Mars, which have led him to some original conclusions worthy of investigation.—*Translated for the Popular Science Monthly from La Nature.*

EDUCATIONAL ENDOWMENTS.

By CHARLES S. ASHLEY.

THERE is so much sound philosophy on the present subject in a story related by that genial publication, the "Arkansaw Traveler," that we may be excused in departing from the severe dignity proper to a sociological essay in repeating it. It seems that down in Arkan*saw* there lives an old man named Billson, together with his son Dan, who is a close student. Billson was naturally proud of his son, and allowed the young man to remain in his room, deeply covered with the grand rubbish of ancient wisdom. During the busy season, when every hoe in the garden-patch was worth its weight in silver, Billson's neighbors would ask:

"Why don't you make Dan help you with your cotton?"

"He can't spare the time from his studies."

"Studying is all well enough; but, do you think it would hurt him much to drop his books for a day or two, and take up a hoe? The grass is gaining on you."

The old man sighed and seriously reflected for many days. One morning he reverentially entered his son's room. Pointing to an open volume that lay on the young man's desk, he asked:

"What book is that?"

"Plato's Philosophy."

"Full of interestin' readin', I reckon."

"As grand thought as was ever expressed."

"Ain't law, is it?"

"Oh, no, it's philosophy."

"Yes, but what is philosophy?"

"O—er—well, it's er—it's the—soul of great men shaped into words."*

"Ah, hah! What does this here fellow Plato propose to larn you?"

"To be great, to look high."

"Yes, but does he tell you what to look at?"

"O—er—yes, he—that is, he tells you to purify your soul."

"Ah, hah! But what does he tell you to do with the body?"

"The body! Why, he scorns the body."

"Ah! Don't appear to have much use for it, eh?"

"He is higher than all things physical."

"Sorter silent on cotton, too, I reckon?"

"Why, father, what can you mean?"

"Wal, I'll tell you. Ain't got nothin' agin Ponto—"

* I pause to remark that I have known many a young person who, like Dan, was studying philosophy, and whose idea of the same was about as precise and intelligent as the above definition.

"Plato," the student suggested.

"Yes. I ain't got nothin' agin him, you understand, and reckon he may be a pretty clever fellow; but I'll tell you what's a fact. He ain't worth his salt when the grass is in the cotton; so, Dan, jus' grab that hoe hangin' in the tree out there, and scorn the grass, and larn the cotton to look up."

"Great goodness!" the affrighted young man exclaimed, "I can't stand it out there!"

"Oh, but you mustn't pay no attention to the body. The sun won't hurt your soul. Come on, or your grub stops."

The young man sighed, and like the scriptural personage, arose and followed his father. Two hours later a panting and perspiring Platonist wielding a heavy hoe was seen striking at the fox-tail grass.

This story illustrates the superstition and ignorance which have characterized the great mass of mankind regarding educational matters. It is a fact at this day that the vast majority of pupils in attendance at our colleges do not know what they want. It is also a fact that the parents who send them do not know what value their children are to get for the sacrifice made. They have a vague idea that their children are to be "educated," and are accordingly to take their place among the first of the land. This simple conception is carefully coddled at commencements, where the public are congratulated on the fact that they are to be taken under the protecting wing of the "educated" (i. e., the college-bred) man. The common people are elegantly assured that they will be supremely blessed, in some mysterious and unspecified manner, by the presence of "educated" men among them; while at the same time it appears that the "educated" man will have a very nice and agreeable job in taking care of the public. And the amazing superstition that a study of books (and those, too, almost irrespective of the wants of either pupil or public) is education, persists in defiance of all sense and experience.

The same simple faith appears in the making of charitable bequests. No statistics regarding educational endowments are afforded by the census, nor are any at hand, hence the subject can not be presented in its full aspect. But we know that endowments are daily announced in the newspapers. Young men and women are to be hired to study theology by means of fellowships, to look at the stars, to study the languages, and the sciences, or whatever the whim of the "benefactor" happens to be. The climax is reached when, as was lately announced in the London "Times," an immense sum is set aside from the ordinary course of business to aid young men in becoming civil engineers. That education, if valuable, should be paid for like everything else of value; that it should stand on the same footing as all other things, and that its value is best secured by its ability to appeal to the spontaneous desires of the public, and to win its financial support precisely as Booth or Patti or Theodore Thomas win their support—that is to say, by re-

ceiving value for value given—seems to be a conception which, though it has reached many people in a confused way, has not yet penetrated educational circles. These, like the clergy in former times, imagine themselves independent of the rules governing other men in the struggle for existence, and demand support as a caste, independently of the quality of the individual service rendered, or the amount of demand for it. This is the attitude of college men as a body. They have not yet accommodated themselves to the new age, which recognizes no privilege. And this feeling likewise governs the law, which still permits men to set up perpetuities, and control the administration of wealth years after they are in their graves, and after a society of which they had no idea has arisen.

The explanation is not as simple as the fact is plain. It is that with the advance of the United States to the position of the wealthiest nation of the earth, the wealthy and fashionable classes have naturally reverted to European standards in education and fashion, and thus a collegiate system which once fulfilled a real need in Europe, has been transplanted into our own uncongenial soil. For it is true that even the churning of Latin and Greek into unwilling minds once had its use; as is also true of slavery, of the feudal system, of church establishments, and of all other things. That use consisted in the social discipline involved in the creation of a class united by common interests and ideas which could assist the ecclesiastics and the police in restraining the barbaric vulgar. When modern educational institutions were founded the great necessity of society was the repression of lawlessness, of private war, and of all the elements making for social disorganization. Under the supreme instinct of self-preservation every nation in Europe put forth vast institutions to uphold order and some semblance of law. The feudal system, ecclesiastical power, monarchy, and education, were the chief engines evolved for this purpose. In turn, or at the same time, they fulfilled the need which produced them; and since then they have each slowly declined and are rapidly being forced to adapt themselves to the changed condition of mankind. But every institution retains the instincts which gave it birth; the tendency of every structure is to persist in that mode of activity with which it starts. So we find the aristocracy of England still "willin'," like Barkis, to take care of the people, in spite of the ungrateful and altogether improper ridicule of men like Mr. Labouchere; and the late book of Mr. Mallock, "The Old Order changes," is extremely interesting and instructive, both as the latest expression of this pleasing willingness and in the ferocity with which it treats those who object to being taken care of.* So with ecclesiastical systems, in their decline as an autocratic caste, the same mediæval instincts show

* Of Japhet Snapper (a caricature of a leading radical politician) he says, "his desire to abolish the aristocracy is only a fermentation of his desire to lick their shoes." This is pleasant.

themselves; and the same resistance to changed conditions appear. In Escott's "England" is an idealized picture of the typical rector, in which the good man's heroic labors are pathetically set forth in such strains that one is reduced to absolute wonder that men like John Bright can be so perverse as to advocate disestablishment; though indeed he might be excused on the ground that the clergy must be prevented from altogether sacrificing themselves on the altar of their country.* And in America a like fact appears in the military and naval service. If the naval officers could have their way, we would at once begin to discount the nations of Europe in building ruinous engines for killing our fellow-Christians; and the soldiers would likewise have an enormous standing army perpetually fighting the air on dress-parade. And now, to come to the immediate subject in hand, the same truth holds with regard to education. The European system was introduced into this country, and, though it has been forced to change very extensively, it has held its ground with wonderful tenacity. The primal distinction from one which would naturally grow up here is not in the subjects offered for study but in the method of maintenance. The European system assumes that people do not know what they need, and that it must be offered to them gratis. In America we recognize the contrary to be true in nearly all the concerns of life—in religious establishments, in the militia, and latterly in most college curricula.

In this paper I propose to pass in review the operation of educational endowments both past and present. Having admitted that the artificial support of education had at one time its social justification, we shall confine ourselves to the inquiry, Have endowments been productive of the progress of knowledge and sound education from the individual standpoint? For it will scarcely be pretended that in these days this mode of education is a necessary means of preserving order. That end is now subserved by commerce and the vast interdependence which complicated and specialized systems of production and exchange involve. The province of education in our day has become narrowed like all others, and—speaking, of course, of higher education—is now simply the bestowal of needed knowledge. We shall address ourselves to the inquiry as to whether endowments are a suitable means for the diffusion of knowledge by a brief examination of the history of the English schools and universities, and by a short study of their present operation in this country.

The history of Oxford is deeply involved with that of the general mass of British society. It is first known as poor and democratic. In the early part of the fourteenth century it is said that as many as

* The Archbishop of Canterbury, for example, sacrifices himself to the extent of taking a salary of $75,000 a year. Every one must feel sorry for the archbishop; especially when it is considered that he has to live in a palace rent free and to endure the terrific labor of crowning kings and the like.

thirty thousand students were in attendance; and Huber, the learned historian of the universities, says that "the intellectual importance of Oxford at that period is universally acknowledged." At this time the university had none but rented buildings, and little or no land. Endowments did not exist, and every teacher was left to find his own level. The Church and the government now attained a more efficient organization, however, and laid hands upon the universities. The means by which the university became a stepping-stone to the Church and an appendage to the government are not very clear. Monasteries and endowments encouraged the cultivation of such learning as the ecclesiastics considered genuine. The Church and the government gradually acquired intimate and stable relations; and the end of the process was that Oxford, and Cambridge as well, became aristocratic institutions, whose aims and ideas were those of the ruling classes, and whose characters became sociological or political rather than educational. Huber* has the following remarkable passage on this point:

"After attaining its greatest external privileges a new process commenced in the university. The number of students diminished but endowments kept increasing, and of course democracy waned rapidly. . . . The university became gradually more dependent on fixed possessions and assumed a new impress. It was of course more aristocratic; and did not wholly escape the deadening influence of worldly goods."

Surprising as it may seem, Oxford seems never since to have attained any considerable importance intellectually. From the writings of a contemporary, we learn that the gownsmen became "swollen in mind" and indifferent to learning. Gradually the university became filled with the younger sons of the gentry, who went to the university as the means of ecclesiastical preferment. It is unnecessary to rehearse the facts here summed up; I do not know that they are seriously disputed. Politically, it is well known that the universities have been millstones on the necks of the English people. No progress has been made that they could prevent. Ever fawning on power, they have made it their principal business to obtain pecuniary favors from the government. In this they have been very successful. They early acquired the sole right of presentation to ecclesiastical livings by the bishops and others, and, according to Professor Thorold Rogers, "there would not remain one fifth of the present number of students" without this stimulus. Professor Newman, the translator of Huber, states the effect of all this on Oxford in our own century. "An artificial monopoly," he says, "is given to a few accomplishments. . . . And here I speak not of the (neglect of the) physical sciences and mathematics—*the taste for all which in the University of Oxford has in very recent years actually declined—but, confining our view to the circle of studies which constituted the original basis of the universities,* it is extraordinary to see the neglect and decay into which the majority

* "History of the English Universities," vol. i, p. 76, English translation.

of them have fallen. . . . I appeal to any Oxonian whether—with the exception of the Latin and Greek languages and a fair proportion of the corresponding history—there is any one of these subjects for which Oxford is even a third-rate school." He goes on to relate that, when he himself was in Oxford, the candidate for the degree of Doctor of Divinity implied no theological learning whatever; "a candidate had simply to read aloud an old composition lent him by the clerk—it mattered not what, so that it lasted an hour—and this was his sufficient scientific qualification." * Parliament has made various imbecile attempts to improve the vast corruption which is in the universities the fountain-head of the English Church, and the Salisbury government have announced another. None of them has reached the seat of the disease, which is the arbitrary bestowal of rewards and positions without service rendered. Class interest has hitherto been too strong for reform, just as it long was in upholding the practice of purchasing commissions in the army; and Oxford, with ludicrous pageant and solemnity, continues to spend its income of above two million dollars in repressing the progress and intellect of England.

It might be expected that the great schools of England—Eton, Rugby, Harrow, Westminster, and others of that class—would display like characteristics; and, indeed, evidence on this point is sufficiently abundant. In 1861 public clamor induced Parliament to appoint a commission to investigate these institutions, and it unearthed a mass of corruption and absurd practices such as staggers belief. Here the facts can only be briefly summarized. It was found that the revenues of the institution were absorbed by those in control. Head-masters received from twenty to thirty-five thousand dollars annually, besides the right of presentation to numerous church livings, and the Fellows contrived to appropriate most of what the head-masters left. There was found to be an astonishing dearth of general culture among the students: few newspapers were read, Shakespeare and Milton were hardly known, and even Scott and Thackeray were too heavy for the "disciplined" brains of most of the students. Science was an unknown field. Music, geography, history, and drawing were likewise conspicuous by their absence. One of the schools introduced mathematics as late as 1845, and one graduate was found who did not know that there was such a thing as the multiplication-table! The same thing appears everywhere.

The quality of beer and mutton which supported the students in their arduous intellectual labors was found to have been uniformly bad through several generations; the practice of giving bad beer and bad mutton had ingrained itself into the noble British constitution, and could not be changed. One of the provosts testified before the committee that he objected to the teaching of science, "because it is scarcely seventy years old." English literature and composition were

* Introduction to Huber, pp. xxv–xxvii.

absolutely neglected. And, to crown all, it was found that even in the classics no satisfactory work was done. Few of the pupils could read even Latin with any ease, and none were ever asked to do so at sight. It would have been useless.*

Certainly no such state of affairs can be found in any American institution. But there are facts in plenty with the same bearing. Dissociate a body of men from their fellow-citizens, set up an independent caste by endowing it financially, and the consequences appear even in a country where public opinion is as omnipotent as here. The difficulty of forcing progressive action on our colleges is a sufficient illustration. We live in an age of unparalleled "passion, pulse, and power"—an age with gigantic problems suddenly laid on it; our civilization is chiefly industrial, and the railway, the factory, and labor organizations are the largest elements of our social life. Would any one believe *a priori* that under these circumstances our colleges would be still haggling over the Greek and Latin question, and that only one of them in the entire country should give instruction on railway transportation, the most important subject now before the public, and the one also on which there is such vast ignorance?† This, however, is only one instance of the disgusting narrowness of the professorial intellect as "stimulated" by endowments. Everywhere we find a total want of connection between the colleges—especially those old and rich—and the life of the people. Go into a university library, and, after listening to the complaints of the librarian about the paltry sums at his disposal, you will find splendid and expensive editions of Percy's "Reliques," Scott's "Dryden," hundreds of volumes of pedantic discussion about Shakespeare, and you will look in vain probably for the great newspapers which so faithfully reflect the nation's life; and "Bradstreets," "The Railroad Gazette," and frequently even "The Century," "Harper's," "The Forum," and "The Popular Science Monthly" will also be wanting. Recent American literature is treated with similar disdain. The want of direct responsibility to the public is felt in all directions. When a railway corporation discovers that a man is incompetent, it discharges him; a newspaper takes care not to retain poor writers. But no incapacity is so great that a college position, once gained, need be lost. Go through any of our great institutions, and you will find that year after year the same complaints have been made by students regarding their instructors. These have produced no effect, because the stimulus of duty not re-enforced by interest is not sufficient. It is a disagreeable thing to discharge a man, and it is not done when the authorities have no personal interest in the matter. Thus college professorships in this country come to a pass

* I shall be suspected of heightening this picture. I can only refer to the report itself for confirmation.

† Yale is the college referred to. Harvard has recently announced a series of lectures dealing with railways.

shown frequently in the "livings" of the English Church—mere sinecures, involving little labor, much reward, and great security for dullness and incapacity.* Relieved from the necessity of rendering service which will be spontaneously recognized, the irresistible tendency of weak human nature is to desist from the hard toil which such service demands, and to take refuge, gradually and unconsciously, in doing what will satisfy the powers that be; in high pretense instead of actual performance, and in pedantry instead of sound learning.

And testimony is not wanting to show that the vast success of Oxford and the aristocratic schools of England in producing ignorant dunces is paralleled, fortunately on a milder scale, in this country. In a recent paper in "The Forum," President Robinson speaks of various disadvantages suffered by himself when in college:

"To add to my misfortune, the most intimate of my friends, though pure in their lives, and morally wholesome as associates, were low in their aims as scholars, satisfied with very little and very superficial work. They had been sent to college to prepare for the ministry, and were fair specimens of the average of a class of men not yet wholly extinct. Selected and aided by beneficiary funds as 'candidates for the ministry,' they seemed to regard themselves as absolved from the duty of high aims as scholars, and dropped into the wretched cant of 'laying aside ambition as unworthy the servants of the Lord.'" "The Nation" comments on this by saying that the same thing "is true of a larger part of the men who go to many of our colleges to-day under similar conditions"—that is, on a charitable basis. And it further observes that, "if he had followed these men out into life, he would have had little difficulty in showing that their effect upon the moral and political influence of the pulpit had also been a misfortune." There is nothing strange in this. Mendicancy is equally bad in its effects on the beneficiary and on the public.

A glance through the catalogues of the leading American institutions will justify the opinion expressed as to the total irrelation bred by endowments between public demand and educational supply. In Harvard, the leading university of the country, we find courses of study on the following languages among others: Hebrew, Aramaic, Assyrian, Arabic, Ethiopic, Sanskrit, Old Iranian, Pali. This in a university which offers little instruction on the greatest problems confronting the people of the present age. And in the University of Michigan, at which I took a degree, the same general facts appear, notwithstanding a closer responsibility to public opinion than Harvard is subjected to. A short time ago I visited the university, going to hear a classmate of mine instruct a class in Lysias. He is an excellent in-

* So it is with endowed libraries. The Lenox and Astor Libraries of New York are good illustrations both of the high expectations with which such institutions are founded, and of subsequent disappointment. They are closed for long vacations, and are open for few hours during their season (and *those* are inconvenient).

structor, but no art can infuse life into the subject. It was perfectly easy to see that the class was deriving no mental pabulum from Lysias, and that their minds were chiefly occupied with their chances of escaping a "flunk." There may be considerable literary merit in Lysias, but the class did not see it or care to look for it. They were exclusively occupied with the difficulty of translation and grammatical construction, and the whole process, as compared with real education, struck me as very like gum-chewing as compared with eating. The empty form is gone through with, but there is no nutrition. And even in the most popular courses, like the "seminary" in English literature, the same fact stands out in bold relief. The class study More's "Utopia," Spenser's "Faerie Queen," and the like, Tennyson's "Princess" being the only masterpiece in the course, except "Silas Marner," which has been written in any recent time. When I visited the class, it was striving, with very little success, to seem interested in Wordsworth's "Excursion." There may have been one member of the class who really had a spontaneous appreciation of the poem, but I do not believe there were more. After visiting even the best institutions artificially supported on the European plan, we are forced to think of the profound remark of Bagehot, that "academies are asylums of the ideas and tastes of the last age."

If the harm done by endowments consisted simply in a support of old-fashioned methods and subjects in education, it would be bad enough. But the trouble does not end there. There is a morbid, or what President Cleveland would call a pernicious, activity about them. What energy they have they use in actively obstructing the march of ideas and of political freedom. Oxford's history in this respect is too notorious to admit of further mention. Harvard, too, can tell her story. She has her Memorial Hall now for her sons who fell in the war of the rebellion; but time was when Senator Sumner was conspicuously slighted by her, and when Wendell Phillips was tabooed. Narrow sympathies, extending only to the prevailing power, have characterized "fair Harvard," as well as Oxford and the established Church in England. This is not due to the individual characteristics of the men who are for the time being in these institutions, but to a general law obtaining among privileged castes and corporations. And at this day, among the most prominent professors, we may find illustrations of this truth. It is not Oxford bishops alone who, from a class instinct, are the perpetual barriers of progress and the ardent champions of all that we have nearly outgrown, whether in education, political economy, barbaric criminal codes, and indefensible wars; in all of which the records of Parliament throw a singularly unfavorable light upon the English successors of the apostles, as may be seen in their adherence to the old education, in their resistance to the reform of the savage criminal code of England in the early part of this century, in their well-nigh unanimous support of the corn laws, and in

their equally united support of such wretched acts as the war on Egypt and that in the Soudan. In our own country our endowed fellow-citizens, the professorial socialists, are a corresponding class. It is the instinct of self-preservation in privileged classes to cringe to power, and to express its sentiments; and when, as in our own day, powerful organizations rise, and, exhibiting a great revulsion toward an ancient form of social organization, seem likely to be in the ascendant, these classes hasten to pay court to the brute force of ignorance and numbers, as in other countries they pay court to the majority of bayonets. It matters not to them that social evolution is a continuous progress toward individual property and rights. It matters not that the English race in England and America have, after centuries of struggle and the sacrifice of countless heroic lives, secured individual immunity from official tyranny. The unprecedented rapidity of our recent advance has favored a reaction, and those last to follow in the wake of progress are the swiftest in retreat. But particular illustrations of this fact are necessary. We might cite the astonishing article of President Seelye in "The Forum," advocating *in America* the establishment of a national church! But we prefer to select the most prominent of the professorial socialists, whose recent utterances on economic topics are extremely interesting from our present point of view.

Mr. Richard T. Ely's "Introduction to the Labor Problem" is apparently a hastily written paper, and it might be unfair to subject it to any close scrutiny, were it not for the confidence with which the most startling statements are made, and the like carelessness exhibited in his other writings. The following is one of the gems of thought found in the place referred to: "The idea of free governments is to stimulate individual initiative and individual industry, but the consequence is that a few clever or fortunate people—often successful because more unscrupulous than others—restrict the activity of their fellows, and effectually repress the freest expansion of the energies of the people."

In the first place, the idea of free governments is not to "stimulate" anybody or anything, but simply the removal of obstacles in the way of activity, and the use of the word shows a fundamental misconception. Passing this point, however, one might suppose from the above that Russia and China, where Mr. Ely's sociological ideas have full sway, are better situated for a free "expansion of the energies of the people," whereas it need hardly be said that individual initiative *is* freest and individual industry *is* most successful where governments interfere least.*

"The ethical duties and the holy privileges of a citizen of the republic must be enforced in season and out of season," further remarks Mr. Ely. This luminous dictum is delivered without explanation; and

* The fact that, since the absorption of the telegraph lines by the British Government, all the improvements have come from America, whereas England had before furnished her full share of them, is a striking illustration.

perhaps it is just as well that none was attempted, for it is greatly to be feared that none is possible. It is worth instancing, however, as exhibiting the sanctimonious pomp and official carelessness of the author's style of writing and thinking.

But our next quotation is more interesting still: "Take compulsory education. The compulsion is a power which gradually lifts [a] people above its own ethical plain" (*sic*).

I confess that this last sentence reminded me of certain Canadian rustics who were gulled into believing that a man could lift himself into the air by pulling at his boot-straps. The parallelism is perfect, and in each case the implied denial of the persistence of force seems altogether *naïve* and unconscious. This passage is especially worth instancing, because it shows the weak point in all Mr. Ely's socialistic ideas. His constant assumption is, that governments can coerce the people—can expend force upon them—without itself being supplied with force by the people. The Government (if written with a capital letter) can support the people," whether the people "support the Government" or not. Now, everybody knows the fact to be, that no machine requires so much "pressure" to keep it going as a government agency. Public clamor has to reach a very high key before great measures are passed; endless log-rolling has to be resorted to before the best claim can be passed upon, or the bill most obviously good be enacted. And probably it is fortunate that this is so, for otherwise we should be even more inundated than at present with foolish legislation. But the point for our present notice is, that our Legislatures and executive agencies are inefficient machines requiring a vast amount of power for a given product, and that, too, of poor quality. This is not an accident, but is necessarily so. Legislative and executive bodies are unevolved in character, unspecialized by long discipline for the work they have to do; and this must continue to be so. And Mr. Ely ignores the commonest facts of daily experience as well as the highest generalization of science in the above quotation and in his whole theory of society, so far as he can be said to have one.

Were it worth while, we might continue quotations of this character *ad nauseam*. "Let us remember," he says, in the same Introduction, "that every hope of a permanent reform in industrial and social life must be illusory unless it has a firm foundation in a lasting state reformation." Let the reader observe the connotation of the terms "industrial and social." Does this mean that Congress is to give a "foundation" (whatever that may signify) for every social and industrial improvement? Congress, which can not even manage the tariff or the currency? In Mr. Ely's papers on railroads lately published in "Harper's," it appears that the State (with the big S) is to "reform" that branch of industry. But discussion is useless. Mr. Ely's expressions are so loose, and his papers ignore the commonest facts to such an extent, that argument is impossible.

We are, however, concerned with the sense or nonsense of the ideas of President Seelye, Mr. Ely, and their coterie of professorial socialists, only in a secondary degree. Our purpose is to show that the old Oxford spirit is being bred again in this country through the agency of highly-endowed educational institutions. Here, as always, where artificial protection is afforded to incapacity and mediævalism, we find the old neglect of facts, the old servility to prejudice and power, the same proneness toward the past, the same complacent carelessness and assurance of statement. Here, as ever, we find the old protective tone, the old ecclesiastical air—the old air of taking the public under the writer's wing. Had we space, numerous passages might be cited showing the patronizing and wholly foreign way in which the laboring-classes are regarded. And, of course, the same class-spirit is shown, as it always has been, in the bearing toward classes who are rising by their own unaided exertions to predominance (not, of course, of the political kind—else malign complexions would grow smiling) in the country. And the resistance of the Oxford bishops to Cobden and to Gladstone is singularly well paralleled by the jealousy shown by our endowed professors toward the great railroad managers, the great bankers and merchants and manufacturers, who are doing more for the comfort and happiness of mankind than any equal number of individuals in the world. And "The Nation's" remark (No. 1110), at the close of a review of one of Professor Ely's books, that "Dr. Ely seems to us to be seriously out of place in a university chair," was, while conceived in the right spirit, not literally true; for such men inevitably gravitate toward such positions.

Now, what is the *rationale* of the matter? Why is it that specially-protected classes acquire such a pronounced class instinct as is found in English clergy, in state officials, and in endowed professors? In the first place, every agency has a tendency to persist in those activities and modes of thought in which it set out; and when new agencies spring out of old ones, the result is the same. Thus, through educational institutions, the eighteenth century forces its ideas on the nineteenth, Europe on America, and Harvard on California and Michigan. Then there is the natural class jealousy, exhibited by all organisms; by France as against Germany, America as against England, labor against capital, spiritualist against materialist, by every man against a rival. And when endowments or state support render a class totally distinct and altogether independent of those influences which govern the rest of mankind, both causes work great effects. The result is similar to the coagulation of the blood caused by tying up a limb and preventing a free circulation within it. First there is annoyance, and then the isolated part becomes the seat of a disturbance which may threaten the life of the organism. I believe that any person who observes the air, the social temper, which surrounds educational institutions, especially those richly endowed, will find the effect

spoken of not only in the government and the corporate character of the institution, but in the personal character of most of its officers. Many, very many exceptions must be made to such a statement; but, in the end it must be acknowledged that that stamp of action known as officialism leaves its mark upon the official; and that the individual as well as corporate influence of institutions thus artificially maintained, and animated by a different spirit and principle from that elsewhere prevailing in the body social, is hostile to the free movement, and an obstacle to a continuous healthful readjustment of ideas in our country.

Any general objection to the existing order of things inevitably meets the query, "What will you put in its place?" It is frequently assumed, so strong is the conservative instinct in mankind, that the objector, if he discovers or points out a disease, should also cure it. This hardly seems just. Nature puts forward one set of agencies for right criticism and another for right construction. Critics are seldom artists, and artists are seldom critics. Still, it is not difficult, in the present case, to give a more satisfactory answer. In the first place, it may be said that the objections brought against the foregoing are generally based on an overestimation of the function of academic education, both in individual and national life. The learned Huber remarks that the revival of learning in the fifteenth century, like the speculative movement of the twelfth century, "was sustained by the co-operation, not of institutions, but of individuals"; and this is also true, he says, "without a doubt, of every intellectual impulse which is animated by an independent principle of life." * This fact is evident enough both historically and from the *rationale* of all progress. I can not think of a single forward movement of society which has not been obliged to overcome the opposition of great educational centers; and hardly an eminent name occurs to me as having been assisted in its high destiny by academic education.† Whether in business, politics, or letters, the world's leaders have not been sent forth panoplied to conquer by their alma maters. It is with intellectual as with other progress. New developments arise, not from fixed types and structures, but by fresh movements from beneath; and the surface crust has always to be broken through before the new experience can displace the old in consciousness, and the new force has to break or bend the old structure in society before it can assume its rightful place. This is so obviously and so universally and necessarily true, that one may be surprised at the wide prevalence of the opposite

* Huber's "History of English Universities," vol. i, p. 216.

† A few Englishmen in several classes may be instanced as either having no connection with universities, or as deriving no profit from them. Burke, Bentham, J. S. Mill, Herbert Spencer, Davy, Faraday, Watt, the Stephensons, Lardner, Turner, Grote, Buckle, George Eliot, Thackeray, Dickens. Gladstone has been fifty years in getting Oxford out of him, and Grant Allen says that Darwin "escaped with comparatively little injury."

superstition. The surprise, however, will disappear on reflection. It has its origin just where reverence for kings, priests, and popes has its source—in the supreme need of mankind in early times for agencies maintaining social order and coherence.

This, however, is not a complete answer to the question, What is the substitute for endowed schools? But it renders the objection much less forcible than it might otherwise be. But if, notwithstanding the small share that institutions of learning really have in our national life, it still be thought that greater provision for them is necessary than commercial motives would lead to, it should probably be said that the best method of support is by direct annual grant from the state governments. Rough as is the relation thus established between a social structure and its function, it is clearly better than complete irresponsibility. Observation of institutions where this system of support is in vogue—as, for example, the University of Michigan—will, I think, strengthen this view. But I do not think there is any evidence whatever that education needs or can profit by artificial aid. Our colleges can be supported as our churches are supported; and, under a free and active business competition, there is quite as much reason to expect educational improvement as there is certainty of the superiority of our free churches over state establishments. But colleges are really an insignificant factor in education. Commerce, travel, newspapers, and books, spontaneously chosen, are the real educators. Whether in general literature or special science, the public is being served by periodicals printed for profit, and by voluntary societies of vast efficiency; and I think both newspapers and magazines might be named as exerting a greater educational influence, both from a public and from a personal point of view, than all the colleges in the country put together. Still further, schools are everywhere springing up on a business basis, because the most efficient men find they can make more money in this way than by bending to the dead level of existing institutions. And, surprising as it may seem at first sight, some of these schools might be named as not only giving better instruction, but as giving it at a smaller cost to the pupil, than endowed colleges, or those maintained by legislative grants. Business-colleges, lecture-bureaus, circulating libraries, magnificent art-stores, are fast supplying public wants, and would do so much more rapidly but for the prestige of the established system. And the genius of commerce, which fills our land with wonders despite foolish legislation and adverse public opinion, will surely triumph, like the Cinderella of our childhood, over her haughty sisters, who are vain rather of their age and status than of their works.

With the instinct of self-preservation, colleges have lately been adopting the elective system. The practical result of the elective system is that only those studies are chosen which fill some want, real or imaginary, and are offered by an agreeable professor. The

final upshot is, then, that the students are made the supreme judges instead of the faculty; and that the professors are put on the natural competitive basis. And though their salaries are still paid by the corporation, the commercial principle is really in vogue, and its nominally becoming so is only a question of time. I remember a significant incident which took place during the last year of my attendance at the University of Michigan. It happened, accidentally, that two students published somewhat severe criticisms on the teaching of the professors in political economy and philosophy. Immediately afterward one of the professors, a very agreeable gentleman of the old school, educated in Germany, and a philosophical imperialist and absolutist to the core, delivered his sentiments on the subject. Amid the mingled cheers and hisses of his pupils, he attacked the presumption of the critical students. It was evident that in his mind things were going very badly. To him there was something wrong about a universe in which young men were permitted to have different opinions from their elders; and it is hardly too much to say that he was enraged. I could not help sympathizing with the vain struggles of an order which is rapidly passing away under the inevitable law of competition, and which, indeed, ought to pass away. And the resistance of President McCosh to *any* concessions to liberalism is an instinctive recognition of the fact that when they are once begun there is no ending. There is no stopping-place, no compromise, between the ancient system and that wherein every student chooses his studies and his teachers, and pays therefor. The small wedge of option being once introduced, there are incessant change and disturbance till this natural equilibrium is reached. If any one institution possessed an overpowering influence, its authority might check the advance for a time, but the competition for public favor between the five or six leading universities is so keen that each one is forced onward; and individuals, however conservative, and however many the degrees and titles that trail after their names, are unable to prevent the rapid adaptation of educational establishments to the demands of the public.

It has been the object of this paper to call attention to the facts that great endowed institutions of learning have not been efficient in the diffusion of knowledge, or as a means of intellectual progress; that, latterly, they have been useless and obstructive to the general march of society toward improvement; that the current system in America is an importation from Europe, and bears a scant relation to our requirements; that our colleges resemble, in their retrogressive characteristics and influences, their elder sisters in Europe; that their status in society is due rather to a superstition than to work performed; and that there is every reason to believe that educational facilities offered on a purely commercial basis, to which the elective system in the end inevitably comes, would be less costly to society as a whole, perhaps even less costly to students, and far more satis-

factory. The policy of the law in giving individuals power to propagate their ideas for an indefinite period after death should be reversed, and their ideas should be put on the same footing as their preferences for individuals, to whom property can be limited for a few years only. In this case the monstrous egotism which leads to a large number of endowments would be cut off; and future generations would not be taxed in order that Jones or Robinson, dead fifty years since, might have the posthumous pleasure of having a college called after him. When competition and change in public sentiment have brought about this state of things, educators will have to let go of the cherished but unscientific idea that their judgment is better than the inclination and judgment combined of the students, and that it is their duty to force dull studies on unwilling minds. And the social organism will then, in this department also, carry on its processes of growth and development, waste and repair, in the same unfettered and natural manner in which the animal organism maintains and enlarges its life.*

SKETCH OF PAUL GERVAIS.

PAUL GERVAIS was eminent as a zoölogist and as a paleontologist. Born in Paris on the 16th of September, 1816, he died in March, 1879, having lived a life exclusively devoted to science. By his entire consecration to study, says M. Blanchard in his "Eulogy," he reached the most enviable positions, conquering them with only his natural talents, courage, perseverance, and assiduity in work; for he had at the beginning of his career neither the resources which make existence easy, nor the certainties which give confidence as to the future. In early youth, yielding to his native tastes, he was accustomed to frequent the woods around Paris, to observe and study natural objects. His first scientific paper was published when he was seventeen years old, in the "Magasin de Zoölogie," and was an account of a new species of Soui, the *Cinnyris Adalberti*. His attention was directed at

* Any one possessing a reasonable knowledge of the general principles of evolution will easily see that the above views as to the lines of future progress are merely corollaries to the general doctrines of social evolution. Every social activity, like every individual habit, passes from the stage where it is the act of the whole organism to that wherein it is specialized and automatic. Every function soon evolves its special structure; and this structure, under normal conditions, automatically draws its nutrition in proportion to its expenditure in the service of the organism. This process is inevitable because it results in a saving of force, and an increase of active power supporting the organism, *as an act by a part is less costly than an act by the whole.* Increased heterogeneity and coherence in general evolution mean, in sociology, increased individualism and free association on lines of spontaneous attraction—that is to say, social evolution consists in a change from socialism to what we call individualism. The recent noisy reaction should not blind us to the great facts of the history of civilization, which is one long record of the decline of the *régime* of status in favor of that of voluntary association.

an early period of his investigations to animals which had been somewhat neglected by naturalists, and the fruit of his studies among them appeared in his work upon "Myriapods and Fresh-Water Polypi." In this work he defined accurately for the first time the characteristics of the animals, and followed out some of the changes which are gone through by certain of the species at various ages. In 1835 M. Gervais was admitted as preparator into the laboratory of comparative anatomy of the Museum of Natural History, and a special direction was given to his studies. Professor de Blainville was preparing a grand work on the bony frame of living and fossil mammals; and the young naturalist, exerting his whole effort in assisting his master, attached himself with marked preference to researches on extinct species, of which he had the satisfaction of describing definitely not a few that had been hitherto unobserved or inadequately studied.

In 1841, according to Larousse's "Dictionnaire Universelle," after having spent ten years in the Museum, according to M. Blanchard, M. Gervais was called to the chair of Zoölogy in the Faculty of Sciences at Montpellier, where he successfully continued his researches; and here he prepared and published his great book on the living and fossil vertebrates of France ("Zoölogie et Paleontologie Françaises," 1841–'52), which was regarded as in continuation of Cuvier's and Blainville's publications on the same subject. He became Dean of the Faculty in 1856; was chosen correspondent of the Institute; and, on the death of Gratiolet, in 1865, became his successor as Professor of Anatomy, Comparative Physiology, and Geology, in the Sorbonne. In 1868 he became Professor of Comparative Anatomy in the Museum of Natural History, "returning as master to the laboratory in which his early youth had been spent." In the collections of this institution he found subjects of a most interesting character which were still awaiting an historian; and applying himself to the tasks thus pointed out to him, he engaged in those researches which resulted in the publication of his excellent work on the fossil mammalia of South America. The remains of aquatic mammalia that lived in the ancient seas having been exhumed in enormous quantities, M. Blanchard continues, a general study of the *Cetaceæ* seemed to impose itself upon him as indispensable to the progress of an essential part of zoölogy. M. Gervais undertook this long and difficult study in co-operation with his friend Professor Van Beneden, of the University of Louvain, and after several years the fruit of their conjoint studies appeared as the "Osteography of Living and Fossil Cetaceans" ("Osteographie des Cétacés Vivants et Fossils").

M. Stanislas Meunier has given, in "La Nature," careful accounts of M. Gervais's principal writings, with estimates of their scope and value. The "Documents pour servir à la Monographie des Chiroptères Sud-Américains" ("Documents in aid of the Monography of the South-American Chiropteræ") included descriptions of many species

which were entirely new. This was followed by numerous accounts of mammals, birds, and reptiles, which were largely inspired by the study of the specimens which Alcide de Orbigny, Eydoux, Soleyet, Castelnaud, and other travelers brought back from their long voyages. The examination of the series of birds led him to general conclusions respecting their natural division. These conclusions, drawn from the character of the skeleton, and particularly of the sternum, have been widely accepted. He interested himself in the study of the geographical distribution and classification of reptiles, in the course of which he made various investigations upon the batrachians, particularly the salamanders and tritons. In connection with his researches in the fishes, he was in charge for twenty years of the administration's experiments in pisciculture in the department of Hérault, the chief object of which was to acclimatize the true salmon, species which were not known to exist in any of the streams emptying into the Mediterranean. In co-operation with M. Walckenaer, he prepared a "Natural History of Wingless Insects" ("Histoire naturelle des Insectes aptères").

M. Gervais's first work in paleontology was the thesis which he prepared for the degree of Doctor in Science, on fossil birds. In it he demonstrated the existence, in the Tertiary period, of birds belonging to several genera common in the present age. Cuvier had proceeded in this line of investigation hardly further than to give approximately the order, and in only a few cases the possible genus to which his specimens might belong. M. Gervais, having better material at his command, was able to make more precise determinations.

In fossil mammalia he made known a new simian, the *Semnopithecus monspessulanus*, a hyena, several deer, a porcupine, and numerous cetaceans. His memoir on the distribution of the fossil mammalia among the several Tertiary beds of France deserves particular mention. It exhibited the association of the different species among the various faunas that succeeded one another, from the earliest Tertiary epoch, corresponding with the lignites of the Soissonais to the period of the large animals whose remains are found in the breccia of the caverns. The author shows that these different faunas, which he makes to number seven, never lived simultaneously, either in France or any other country, and that no species was common to more than one of them. The fauna which left its bones in the breccia is the only one which is not entirely extinct. Some of these faunas present only animals of terrestrial species, while others furnished in some of the beds both marine and land species. This feature gave useful indications for determining by the comparison of the land species buried in the marine beds with those which are found at other places in fresh-water deposits, the contemporaneity of land and marine animals for each epoch. It also enabled M. Gervais to determine, under certain conditions, the comparative age of the two kinds of formations. Contrary to the opinion of some

paleontologists, the author showed that real cetaceans were not yet known in the deposits anterior to the Miocene. To M. Gervais are owing, in the study of fossil reptiles, some valuable observations on the footprints of the large batrachians called *cheirotherium* in the Triassic sandstones of Lodève.

Most of M. Gervais's publications were both zoölogical and paleontological. Some were of a more general character. Among these was the "Medical Zoölogy" ("Zoölogie Médicale"), which was published conjointly by him and M. Van Beneden in 1850, and is remarkable for the prominence given to the lower animals and to the theory of parasitism which is developed in it; and a natural history of the mammalia ("Histoire Naturelle des Mammifères"), 1855, in which attention is given to the habits of animals, and to their relations to the arts, commerce, and agriculture. This work, which is in two volumes, abounds in original observations, the fruit of the personal researches of the author, which have in many instances modified the views previously held by mammalogists. He was also the author of "A Theory of the Human Skeleton" ("Théorie du squelette Humain"), 1856; of the "Metamorphosis of Organisms and Alternating Generations" ("De la Metamorphose des Organisms et des Générations Alternantes"), 1861; on the "Antiquity of Man" ("De l'Ancienneté de l'Homme"), 1863; of "Elements of the Natural Sciences" ("Éléments des Sciences naturelle"), 1856; and of many notes, memoirs, and articles in the "Dictionary of the Natural Sciences," "Patria," "A Million Facts," "The Jardin des Plantes," and "La Nature." The wide range of subjects covered in these books testifies to the extent of his knowledge and the diversity of his talents. "In a science prodigiously vast," says M. Blanchard, "he showed himself familiar with most of the subjects, and was accounted among the most erudite." M. Gervais was elected to the Academy of Sciences in January, 1864, and with this he gained one of the great objects of his ambition. After working for nearly forty-five years, to the great profit and advantage of science, he died, from an illness of several months' duration, as poor as he had been in the earlier days of his career.

Mr. J. G. Ellis has criticised, in the "Educational Weekly," Dr. Wilson's theory that a new American race is to be produced by the absorption of the Indian race with the white. Admitting, he reasons, that the white American race is acquiring peculiar characteristics, and that these are not unlike those of the Indian, may it not be the work of the American environment, rather than that of intercrossing with Indians, of which there is no sufficient evidence, but which is contradicted by indisputable genealogies in some cases where the approach to likeness is apparent? Sir Charles Dilke asserted, in his "Greater Britain," that the white American race was growing like the red Indian. The assertion seemed broad and strong, but something of the kind seems to be indicated in this discussion.

CORRESPONDENCE.

MEN'S AND WOMEN'S BRAINS.

AN answer to Miss Helen H. Gardener and the "Twenty of the Leading Brain-Anatomists, Microscopists, and Physicians of New York."

Editor Popular Science Monthly:

DEAR SIR: In the June number of the "Monthly" I find a communication entitled "Sex and Brain-Weight," signed Helen H. Gardener, and indorsed, as she says, by "twenty of the leading brain-anatomists, microscopists, and physicians of New York," which assumes to be in some measure a reply to my paper, in the April number, on "Brain-Forcing in Childhood." The tone of the letter is so bad, and it is written in so unscientific a spirit, that I have hesitated whether or not to notice it with an answer. But, lest silence should be held by some to imply that the assertions of the writer of the letter in question are entitled to weight, I have thought it better to ask the indulgence of a little space in your columns. I will premise by saying that I have no disposition to enter into a controversy on a subject that is at present, so far as I am concerned, of altogether secondary importance to the one to which my paper on "Brain-Forcing in Childhood" mainly relates, and that I shall not again in the present connection ask any similar favor at your hands.

With Miss Gardener's opinions of my antagonism to the female sex I shall not stop to argue. I have only to say that no one is more in favor than myself of woman's intellectual advancement, and that in all that I have said or done in recent years in relation to this subject I have recognized the natural equality of woman's brain with that of a man so far as mentality as a whole is concerned. I have only contended that her brain is different from that of man, and that *a fortiori* her mind must also be different. I am in favor of "girls and women" using all the means of development of which they can avail themselves, and which are of such a character as to fit them for the duties of their sex. I am very sure that in many respects—as, for instance, in the study of music, of painting, sculpture, literature, and many of the sciences—their opportunities are as great as those of men, and I regret that they have not made better use of them. I am opposed to their study of military science, or of such branches of knowledge as they are not likely to use in their lives, as a mere system of routine, just as I am opposed to similar procedures in boys.

Quoting from my paper, I repeat, "The skull of the male of the human species is of greater capacity than that of the female, and it is a singular fact that the difference in favor of the male increases with civilization."

Now let me bring forward some of the authorities for this statement in order that Miss Gardener may submit them to the "twenty of the leading brain-anatomists, microscopists, and physicians of New York," whoever they may be, who appear to have as little knowledge of the subject as she has herself.

I may say that there is no authority known to anthropologists that denies that the capacity of the average male skull is greater than that of the female. Miss Gardener and the "twenty leading brain-anatomists," etc., have only to refer to the "Revue d'Anthropologie," tome ii, series 1873, No. 3, page 481, for citations on this point in regard to twenty-six different nationalities, and in every one of them the difference is marked. Relative to the second assertion, that the difference is greater in the civilized than in the uncivilized nations, I find in that table that Huschke determined that in twenty-one German men the average capacity of the cranium was 1,538·76 cubic centimetres, while the average in eighteen German women was but 1,265·23 cubic centimetres, showing a difference of 273·53 cubic centimetres in favor of the male skull. In twenty-one male English skulls, Barnard Davis found the average capacity to be 1,595·33 cubic centimetres, while in eighteen female English skulls it was only 1,372·54 cubic centimetres, a difference in favor of the male skull of 272·79 cubic centimetres.

Looking now at the lower races, we see that Barnard Davis, in twelve male Australian skulls, found the average capacity to be 1,316·85 cubic centimetres, while in the skulls of three Australian women the average was 1,273.08 cubic centimetres, a difference of only 43·77 cubic centimetres. In nine male negroes of Dahomey, he found the average skull capacity to be 1,493·88 cubic centimetres, and of three female negroes 1,412·33 cubic centimetres, a difference of 81·55 cubic centimetres. I could easily quote other figures to a like effect, but the foregoing are sufficient to establish the correctness of my assertion. If Miss Gardener and the "twenty leading brain-anatomists," etc., desire further information on this point, I would refer them to the "Dei Carateri Sessuali del Cranio Umano,"

by Paolo Mantegazza, published in the "Archivio per l'Anthropologia," vol. ii, 1872, or to the elaborate critical review thereof by M. A. Dureau, in the journal which I have already mentioned.

Miss Gardener appears to have looked into a copy of Topinard's "Anthropology," and perhaps the "twenty leading brain-anatomists," etc., have done likewise, though that is doubtful. In any event, let her and them turn to page 145 of the English edition, and they will find the following words:

"The head of the woman is smaller and lighter, its contours more delicate, the surfaces smoother, the ridges and processes not so marked. The superciliary arches are but little prominent; the external half of the superior orbital border is thin and sharp (Broca). The forehead is vertical below, projecting above. The occipital condyles are small, as also the mastoid and styloid processes. The zygomatic arches are slender. The cranium in its *ensemble* is less high and longer," etc.

Some of these differences are absolutely inseparable from corresponding differences in the form of the brain.

Then, if they will refer to Carl Vogt's "Lectures on Man," page 90, they will find the differences between the male and female crania, due to civilization and barbarism, stated to the same effect as I have given them—that is, that they are more marked between the sexes in the civilized than in the uncivilized nations.

Now, in regard to the cause of this condition, Miss Gardener says that I "hold it to be a natural and unalterable difference in the brain-mass itself!" How she came to venture upon this assertion is a mystery to me, and I can only attribute it to that defective logical power which appears, for the present at least, to be a characteristic of most female minds. So far from saying anything of the kind, I offered two entirely different explanations of its cause: one to the effect that civilized women had not availed themselves of the advantages offered them, and hence had not developed their brains *pari passu* with those of men; or else that the work of barbarous men being very similar to that of their women, there had not existed the same necessity for an increased development of their brains.

Then Miss Gardener, without any notice to the reader that she has changed her source of information relative to my views, proceeds to quote from a paper of mine written several years ago, on the subject of "Women in Politics." To be sure, she mentions previously that she intends to quote from two of my papers; but no one reading her letter could believe otherwise than that she was citing extracts from the paper on "Brain-Forcing in Childhood," published in "The Popular Science Monthly" of April last. I have no copy of the other paper before me, it having been published in the "North American Review" several years ago; but doubtless she gives the words correctly, and I state them here with her comments as I find them in her letter:

"Dr. Hammond asserts, again, 'It is only necessary to compare an average male with an average female brain *to perceive at once how numerous and striking are the differences existing between them*' (the italics are mine). He submits a formidable list of striking differences, which include these: 'The male brain is larger, its vertical and transverse diameters are greater proportionally, *its shape is quite* different, the convolutions are more intricate, the sulci deeper, the secondary fissures more numerous, the gray matter of the corresponding parts of the brain decidedly thicker'; of this latter part the doctor modestly says that 'the evidence is not so full as might be desired.' But, as if all these were not quite enough to enable the merest novice to distinguish a male from a female brain, he offers these re-enforcements: 'It is *quite certain*, as the observations of the writer show, that the specific gravity of both the white and gray substances of the human brain is greater in man than in woman.'"

From this last remark she proceeds to draw the inference (in which doubtless she is sustained by the "twenty leading brain-anatomists," etc.) that the greater prevalence of insanity among men than women is the result of the greater specific gravity of the brain, forgetting that the life of man is so much more active than that of woman, his liability to injuries so much greater, his addiction to the excessive use of alcohol so much more common, and his habits generally so much worse, as to constitute the real reasons why he is more liable than woman to become insane.

Moreover, she appears to be entirely ignorant of the facts, as are likewise doubtless the "twenty leading brain-anatomists," etc., that the specific gravity of the brain is increased in insane women as well as in insane men, and that, instead of being a cause, it is probably a consequence of the morbid processes to which the brain of the insane is subjected.

But, in regard to the description which I have given of the average female brain, I stand ready to prove its correctness, not, however, in the rough-and-tumble fashion proposed by Miss Gardener, but by a process by which all such determinations are made by those who know what they are about.

Suppose, for instance, I am describing a woman's thumb, and pointing out its differences from that of a man. I should say that it was shorter, smaller in circumference, that its articulations were not so

prominent, that the processes on the bones for the attachments of muscles were not so well marked, that its muscular structure was more delicate, that the skin was softer, and finer, and freer from wrinkles, that the nail was longer in proportion to its width than that of man. Such would be the description of an average female thumb, as I see thumbs belonging to the ladies of my acquaintance.

Now, following Miss Gardener in the offer which she makes, and according to which—by my ability to select rightly in every instance—I am to gain or lose my case, I make this proposition to her :

I will agree to furnish twenty well-preserved thumbs, marked in cipher, if subjects can be obtained for the experiment, Miss Gardener or her "twenty leading brain-anatomists," etc., to divide the male from the female thumbs, by applying any knowledge they may possess on the subject.

Doubtless Miss Gardener and the "twenty leading brain-anatomists," etc., know a male from a female thumb when they see them, but I am quite sure that by judicious selection, I should be able to confound their judgment. I should take some of the male thumbs from small, delicate men who had never done any hard work, and who had taken good care of their hands by wearing gloves and availing themselves of the services of a manicure, while I should select some female thumbs from women whose hands are hardened and enlarged by exposure and toil, and to whom nail-brushes and soap-and-water are rarities. I am quite safe in saying that Miss Gardener and the "twenty leading brain-anatomists," etc., would find it impossible to select the ten male from the ten female thumbs, and I am equally certain that there is not an anatomist of the brain kind, or any other variety, who could accomplish the feat.

That there are female brains that are larger than male brains, of altogether superior development, and the possessors of which have greater intellectual power than is exhibited by some men, neither I nor any any one else, so far as I know, has ever denied. Miss Gardener can not be in ignorance of my views on this subject, for she quotes my words "average male and average female brain," and it is to the "average" female brain only that my description applies. A fair proposition would be the following, and, if Miss Gardener, from the resources at her command—"the collections" of the "twenty leading brain-anatomists," etc.—will supply the brains, I will agree to stand or fall by the result. Weigh one hundred male brains and then one hundred female brains: if the average weight of the male brains is not several ounces greater than that of the female brains, I lose my case. The only condition I make is that I shall be present when the brains are selected and weighed.

It is scarcely necessary, however, to repeat an experiment that has been performed by many anatomists in all parts of the civilized world. Thus, Welcker's observations show that the average male brain in Europeans is a little over forty-nine ounces, and the average female brain a little over forty-four ounces, a difference of about five ounces. The proportion existing between the two is therefore as 100:90. Huschke found the brains of adult man and woman to weigh respectively 1,410 grammes and 1,272 grammes. His observations, therefore, coincide very exactly with those of Welcker.

Calori not only found that the brain of man is heavier than that of woman, but he discovered the fact that the difference exists no matter what may be the form of the skull. Thus in men with brachycephalic skulls, the average weight of the brain was 1,305 grammes, while in brachycephalic women it was only 1,150 grammes. In the dolicocephali the average weight of the male brain was 1,282 grammes, whereas that of the female brain was 1,136 grammes.

Broca, in his paper "Sur le volume et la forme du cerveau," arranges from Wagner's elaborate table one which shows that this difference exists for all ages from twenty-one years to sixty and over. The results are given in grammes in the following table:

AGE.	MEAN WEIGHT OF BRAIN.	
	Men.	Women.
From 21 to 30 years....	1,341·53	1,249
From 31 to 40 years....	1,410·36	1,262
From 41 to 50 years....	1,391·41	1,261
From 51 to 60 years....	1,341·19	1,236·13
From 61 upward.....	1,326·21	1,208·43

In fact, all authorities, without exception, save Miss Gardener and the "twenty leading brain-anatomists," etc., agree that the average European male brain is about five ounces heavier than the average female brain.

Another test that I am willing to abide by is the following, relating to the other characteristics that Miss Gardener quotes as having been laid down by me:

Let her, from the stores at her command, allow me to select from at least one hundred specimens an average female brain, and from a like number an average male brain. I will agree to point out to a competent brain-anatomist—not one of the "twenty," however—all the differences for which I have ever contended. By that test also I am willing to stand or fall.

I have never said, as Miss Gardener charges, that the sex of an infant could be determined by its brain, though Rüdinger declares that a typical point of difference be-

tween the male and the female brain can often be found at the seventh or eighth month of foetal life, and that the male has the frontal lobe better developed than has the female, and that there is an earlier development of the secondary fissures in it, and in the parietal lobe.

I commend this matter to the serious consideration of the "twenty leading brain-anatomists," etc. I scarcely believe that any one of them, without reference to the "physical sex differences" referred to by Miss Gardener, could tell the sex of a three-months-old infant by a minute inspection of all the rest of its body.

A word more in relation to the subject of the comparative weight of the brain in the two sexes. Miss Gardener and, presumably, the "twenty leading brain-anatomists," etc., deny that there is any superiority of brain-weight in the man over that of woman, and she instances the fact that the difference in the weight of some men's brains is greater than that existing between that of the sexes. No one questions that matter, so far as I know, but certainly nothing of any importance to her case is to be drawn from the fact. A like condition exists in regard to almost all parts of the body. Thus the average foot of a woman is smaller than the average foot of a man, yet the difference between the feet of some men is greater than the average difference between the foot of man and woman. The average ear of a man is larger than the average ear of a woman. Yet some women have prodigious ears, far exceeding in size the ears of some men; it would certainly not be correct to assume from these facts that a woman's foot or a woman's ear is larger than the corresponding members in man. It is with averages deduced from a large number of observations that we have to deal in matters of this kind and not with individual examples.

Dr. Thurnam gives the average brain-weight of ten men who were remarkable for their intellectual development as 54·7 ounces, among them that of Cuvier, 64·5 ounces; Abercrombie, 63 ounces; Spurzheim, 55·6 ounces; Daniel Webster, 53·5 ounces; Lord Campbell, 53·5 ounces, and Chalmers, 53 ounces. Now, let Miss Gardener and the "twenty leading brain-anatomists," etc, search the records of anthropology and their own immense collections for the brain of a woman weighing as much as the least of these, that of Dr. Chalmers. I venture to say that there has never been in the history of the whole world a female brain, free from obvious disease, weighing more than fifty-six ounces, whereas there have been many male brains exceeding this by several ounces.

Next, in regard to the relative and absolute brain-weights in the two sexes and in animals generally, Miss Gardener shows that she is ignorant of the points involved. She quotes me as saying, "Numerous observations show beyond doubt that the intellectual power does not depend upon the weight of the brain *relative to that of the body* so much as it does upon *absolute brain-weight*." (The italics are Miss Gardener's, who, not content with exercising the feminine proclivity of italicizing what she writes, takes that liberty to no small degree with what I have written.) This is true, but she does not understand in what its truth consists, for she goes on to assert that in accordance with its dictum the brains of the whale and of the elephant, being of vastly greater weight than the brain of man, the animals possessing them should be superior to man in intelligence. Here she very disingenuously or very ignorantly attempts to make it appear that I have declared absol te brain-weight, regardless of species and genera, and without reference to the structure of the organ, to be the test of intelligence; whereas, in everything that I have ever written with reference to this point, I have invariably expressed the diametrically opposite opinion. But, if the brain of a whale or that of an elephant had as large an amount of gray tissue and as complex a structure as that of man, it is very certain that *then* the whale and the elephant would stand at the head of all animated nature, and that man would be their slave. "The elephant, which disports himself for the amusement of small boys and the enrichment of Mr. Barnum," would be quite capable of causing the small boy and Mr. Barnum to amble, and gyrate, and to stand on their heads for his—the elephant's—amusement and that of his wife and children. It is not only in size that the male brain differs from that of woman, but that its structure and arrangement are also different.

The *absolute* brain-weight is, therefore, of little consequence, except when it relates to animals of the same species. A whale, with a brain weighing six or seven pounds, would be a more intelligent whale than one with a brain of four or five pounds. A man with a brain weighing sixty-five ounces is potentially a more intellectual man than the one with a brain of thirty-five ounces. In three individuals of very feeble intelligence Tiedemann found the weights of their brains to be 19¾, 25¾, and 22¼ ounces, respectively. Mr. Gore has reported the case of a woman, forty-two years of age, whose intellect was infantine, who could only speak a few words, whose gait was unsteady, and whose chief occupation was carrying and nursing a doll. After death the weight of her brain was found to be but ten ounces and five grains.

As to relative brain-weight, I do not attach much importance to it, as it is subject to variation according as the individual in-

creases or diminishes in weight. Thus, if a man or a woman weighing one hundred and fifty pounds has a brain weighing three pounds the proportion of brain-weight to body-weight is as 1 : 50. But, suppose the person loses fifteen pounds in weight, then the proportion becomes 1 : 45, whereas if there should be a gain of a like amount the proportion would change to 1 : 55. In the first instance, if relative weight has anything to do with intelligence the mental power would be increased, while in the other case it would be diminished. Of course, no such change takes place.

Many years ago I made several thousand observations in regard to the weight and other qualities of the brains of various species of animals belonging to the classes of reptiles, fish, birds, and mammals. In these investigations I went over to a great extent the ground previously traversed by Leuret, and in some respects made new observations. I found among other interesting facts that the brain of the canary-bird, reared in the United States, was in weight as compared to the body as 1 : 10·5, and in the Arctic sparrow as 1 : 11. These little animals have the largest brains relative to the body of any others yet examined. To pretend that they are superior in intelligence to man, in whom the weight of the brain relative to that of the body averages 1 : 36·50, is, of course, ridiculous. Yet that is the conclusion to which Miss Gardener, and presumably the "twenty leading brain-anatomists," etc., would have us come.

Broca declares that the difference in weight between the brain of woman and that of man is not due alone to the smaller size of her body, but to the additional fact that woman is in the mean, when compared to man, a little less intelligent; a fact, he says, which should not be exaggerated, but which is nevertheless real. This is going somewhat farther than I have ever gone, but what Broca says in a matter of anthropology is worthy of serious attention.

When Miss Gardener says that I make relative difference "count for a great deal" when existing between two men, she passes the limits of correctness. I have never said anything of the kind.

One more point, and I have done. I stated, in the paper on "Brain-Forcing in Childhood," that the human head does not grow after the seventh year, and Miss Gardener, with the assistance of the "foremost brain-anatomist of New York," is quite facetious over the assertion. Instead of *head* I should have said *brain*, and then the point involved would have been more correctly stated; for the scalp, muscles, fasciæ, etc., of the head have nothing to do with the issue which concerns the mind only as derived from the brain. In regard to the growth of the brain in size and weight, there is abundant authority for the statement that it ceases to advance at or about the seventh year. Soemmering states that the maximum is attained at three years. The brothers Wenzel, at between six and seven years; and Tiedemann, at between seven and eight years. Other observers have arrived at different results, but there is room for a difference of opinion on the subject, and Miss Gardener should have been aware of the fact when she dismissed the statement as though it were entirely unauthorized.

That the brain ceases to grow at a comparatively early age is abundantly established by the observations of several competent brain-anatomists. Thus, Dr. Boyd, who based his conclusions on the examination of over two thousand brains, found the average weight to be, at the age of from ten to twenty, 48·5 ounces—the maximum weight for all ages, and four ounces heavier than in persons whose ages ranged from twenty to thirty.

Broca, quoting from Wagner's tables, gives the mean weight in persons of from ten to twenty years as 51·7 ounces—heavier by 4·4 ounces than in persons from twenty to forty years of age.

The average weight of the brain in forty-seven persons of English, Scotch, and German nationality, as given by Thurnam in one of his tables, is 49·6 ounces in those whose ages range from ten to twenty years—a weight considerably in excess of that shown for any other period of life.

The general truth of the assertion made in my paper on "Brain-Forcing in Childhood," that "the brain of a child is larger in proportion to its body than that of the adult" is, therefore, not only established, but the additional fact inferentially stated, that the brain is absolutely larger in childhood than in adults, is shown to be correct.

And now I must bring this communication to a close, feeling that I have given more attention to Miss Gardener than she and the "twenty leading brain-anatomists, microscopists, and physicians of New York" deserve, and advising them that before they again rush into print they make themselves to some extent acquainted with the elementary truths of the science of anthropology.

WILLIAM A. HAMMOND.

THE EXPLOSION AT BRIGHTON, ILLINOIS.

Editor Popular Science Monthly:

SIR: The letter of Mr. A. O. Fay, published in No. 182, seems to call for a few words in reply, for Mr. Fay appears to have mistaken the purpose of the article to which he refers. In the first place, the entire aim of my article in No. 180 was to present the phenomena connected with the explosion of August 29, 1886, and not, as Mr. Fay seems

to think, to generalize from a single phenomenon, nor to denounce the methods of building magazines at present adopted. A careful re-reading of the article in question, in the light of Mr. Fay's letter, fails to reveal any such denunciation, or illegitimate generalization.

In reference to the proper construction of powder-magazines, your correspondent clearly condemns the method adopted at Brighton, as shown in the three magazines personally examined, and which I was informed, by the agent in charge of one whose walls were injured in the explosion, was the plan of all. In this, of course, my source of information may have been at fault. But there is not one word in my article which can be tortured into a condemnation of this form of construction, though I did say that "a recent occurrence dangerously near Chicago has shown that it is by no means sufficient" as a matter of protection, and the town of Lake took a similar view. What I did characterize as *very strange* is the omission of any protection against lightning, and I may add that one of this same group of magazines was destroyed by lightning before, I think in 1879, though I have not the date at hand.

Then Mr. Fay says that "the simplest knowledge of the properties of dynamite would have prevented Professor Griffin from attributing the non-explosion of other magazines in the vicinity to the fact of their being beyond the *limits where displacement would not appear*." The words italicized are quoted in a garbled form, which gives them a very different meaning. Originally, they stood as parts of two sentences. This is an easy way of avoiding an explanation of the phenomena. My article suggests an explanation, does not give it as the only explanation; but there were the phenomena, and to deny my explanation, without any suggestion of another, is a good illustration of the method of destructive criticism now so popular: why does not Mr. Fay give his own explanation? Facts are sometimes stubborn things; and the circle of magazines and other buildings uninjured while those nearer the wrecked magazine were destroyed and those farther off were wrecked, is a fact.

I am very glad to be informed of my ignorance of the fact that other substances have taken the place of infusorial earth in the manufacture of dynamite; it would have been more gratifying had Mr. Fay told us what those substances are—or is it now a "trade secret"? But I am at a loss to understand what he can mean by his statement that "it would practically be impossible to find offered for sale by any manufacturer or dealer any dynamite, in the compounding of which earth or any other inert matter had been used." Does dynamite, as now made, contain some substance that reacts chemically upon the nitro-glycerine? If so, the public would undoubtedly be glad to know it, as the danger in the storage of the substance is probably increased thereby.

Mr. Fay's method of quoting parts of sentences and making them appear as used in reference to different points from those to which they were applied does not seem to me quite fair. Yours truly,

LA ROY F. GRIFFIN.

LAKE FOREST, ILLINOIS, *June* 8, 1887.

EDITOR'S TABLE.

SCIENTIFIC ORTHODOXY.

ONE of the accusations brought by the Duke of Argyll against Professor Huxley in the discussion that lately took place between these two representatives of very different lines of thought was—to put it plainly—that the professor was himself half in rebellion against a kind of scientific orthodoxy that has been established in these later days, and was only waiting until the movement against it now going on among the younger men of science had gathered a little more strength, in order to declare himself. The professor warmly, and with good reason, repelled the implied charge of insincerity, and asked what were the signs or proofs on any such scientific tyranny as his Grace referred to. He had himself a pretty wide acquaintance with scientific men, young and old, and if they were under any constraint that prevented them from uttering their opinions and conclusions with the utmost freedom, he was not aware of it. There was really no foundation, we may safely aver, for the duke's taunt as regards men in the higher walks of science. These pursue their researches with no object save that of the advancement of scientific knowledge. They give their facts to

the world just as they present themselves. If there is anything a scientific man labors to be exact in it is in the description of what he has observed. He knows that, if he is inaccurate here, some one will go over his work and discover and expose his errors, thus destroying in a large measure the credit he might otherwise reap from his arduous investigations. No; there can be no question that men of science give the world pure facts as far as they are able; probably no men, not even the clergy, work under so deep and constant a sense of responsibility for the exhibition of the truth without any admixture of fable.

The weaving of facts into theories is, however, another matter, and here undoubtedly a certain personal element may come into play. When Darwin's theories were first broached, all the world, nearly, cried out against them. They were demolished a countless number of times, not only in theological but in scientific periodicals. The world was under the influence of the special-creation hypothesis, and the facts and reasonings of Darwin fell far short, even in the minds of the most of those who read his work, of shaking their faith in the old system of thought. The seed sown was not, however, trampled out of existence, as it might have been in an earlier age. It took lodgment in some minds, and it was not long in showing that it possessed a strong principle of vitality. To-day evolution, in a wider sense than Darwin himself was at first prepared for, is the dominant philosophy. No doubt it was to this philosophy that the duke referred when he hinted at the existence of a kind of intellectual tyranny in the world of scientific thought. It may be, of course, that just as evolution was opposed in the past on account of its novelty and its disagreement with accepted theories, so, now that it has gained a certain prestige, it may receive the adhesion of some who like to be on what appears to be the stronger side, and who may support it in the spirit of partisanship rather than of conviction. How this is to be avoided, while human nature remains what it is, it is difficult to see. Every school of thought that ever existed in the world has had, in addition to its reasonable and convinced adherents, other adherents, in whom the spirit of sect and party has been much stronger than the love of truth. But while we may admit that the evolution philosophy has not escaped, and is not likely to escape, the fate of philosophies in general in this respect, we may very confidently assert that no one to-day who is capable of making any original investigations that might have a bearing on the doctrine of evolution is in the least likely to be unduly influenced by any weight of authority on the side of any particular theory. There never was an age when, in matters scientific and philosophical, there was so complete a "liberty of prophesying" as there is to-day. To talk, therefore, of "scientific orthodoxy," as some do, with the intention of suggesting a parallel with theological orthodoxy, is altogether unfair and misleading. There are no courts for the trial of scientific heresy. The only penalty any man incurs for putting forth inaccurate statements of fact or inconclusive reasonings is that, upon the exposure of his errors, his scientific standing is more or less compromised according to the gravity of the case. No scientific worker can be condemned by the mere *ipse dixit* of any authority however distinguished: the appeal to facts lies open to the humblest citizen in the republic of science. Here truth is Cæsar, and there is no divided empire.

But, while Science does not set up any unalterable code of opinion, while it does not seek to withdraw any theory or hypothesis whatsoever from the control of verification, it has its own way of looking at things, its own methods of testing what is proposed for accept-

ance; and in the application of these methods it shows a rigor which, by ill-prepared minds, might be mistaken for dogmatism. It insists upon an exact definition or delimitation, so to speak, of the object to be considered. "*What* are we talking about?" is a question always in order. It declines to have any dealings with things that are in their nature inaccessible to observation. It refuses to convert sentiments into convictions, or to build assurance upon doubtful analogical inference. It insists upon stopping short just where the facts stop short, and where, therefore, further verification fails. It shuns the dead-reckoning of metaphysical argumentation, and is no less guarded in its denials than in its affirmations. What it can not disprove it will not deny, any more than it will affirm what it can not prove. But if, because a statement or theory can not be disproved, any one wishes to claim that it is proved, Science protests, just as it would do if one were to pretend that, because a thing can not be proved, it is disproved. On every occasion Science says, "Let us take an exact measure of the facts, and let our words conform thereto." It is this severely truthful attitude which draws down upon men of science so much disfavor in certain quarters. If the scientist would only be a trifle accommodating, and where he sees but little would consent to believe much; if he would only accept the currency of confused thoughts and indeterminate expressions; if he would administer metaphysical comfort instead of constantly pointing to the unalterable and demonstrable conditions of human life—he would be more popular with the unthinking multitude, and even with some would-be leaders of thought. But the scientist knows that, if there is any solidity in the edifice of science to-day, it is due to the firm attitude his predecessors, and in part his contemporaries, have maintained toward pleasing and popular errors—to their determination to see the truth, and to bear witness to it, and to nothing else. We may say, using the words in a certain accommodated sense, that "scientific orthodoxy" requires that this attitude shall be maintained. Not to take every possible means for the elimination of error would not be "orthodox" from a scientific point of view; but further than this we can scarcely go in the use of the term. There need be no fear that the progress of knowledge will be checked, or that originality of view will in any way be repressed. The world never had so splendid a generation of scientific workers as it has to-day; and never, as we have already said, was scientific work being done under less restraint, or less undue influence from any kind of personal authority.

PHYSICAL CULTURE AND MORAL REFORM.

It is impossible to read without intense interest of the experiments made in the New York State Reformatory to ascertain whether the moral and mental faculties of criminals might not be roused, and to some extent developed, by a judiciously arranged course of physical exercise. It appears, from the report furnished by Dr. H. D. Wey, that these experiments have been attended with marked success: mental growth has been promoted, and moral control has been increased as a direct result of the physical training administered. Accepting these statements as correct, as we are quite prepared to do, we see vast possibilities opened up of moral reform among a class of the population whose deficiencies have hitherto been the despair of philanthropists and philosophers. The true spirit of humanity was probably never stronger in any man than in Tom Hood; and yet even he was disposed to leave criminals to their own darkened intelligences and evil dispositions.

"'Tis sorry writing on a greasy slate,"

he says in his address to Mrs. Fry, the benevolent Quaker lady who interested herself so deeply in the inmates of jails and penitentiaries. He admired many things about that amiable lady. "I like," he says—

"Your dove-like habits and your silent preaching;
But I *don't* like your *Newgateory* teaching."

"Nugatory" Tom thought it, and nugatory, indeed, the great mass of such teaching has been, as prison chaplains would themselves confess. But if it is the case that the energies of the mind and of the moral nature are sadly cramped and confined through imperfect physical development and abnormal physical habit, what may we not hope for if, by proper gymnastic exercise and sound sanitary conditions, we are able to remedy, to a great extent, these bodily defects? The idea that body and mind work together, and that it can not be well with the one if it is ill with the other, was a commonplace among the ancient Greeks; but for ages the truth was lost sight of, and was indeed supplanted by the antagonist error that if we would cultivate and develop the soul we must oppress and dishonor the body. We are now working back to the Greek point of view; and, with the exact methods of modern science to aid us, may be expected to turn whatever of truth it contains to better use than they did. The Greeks held, empirically, that rhythm of sound and rhythm of motion —particularly simple rhythms free from all *bravura*—had a regularizing effect upon the thoughts and a moderating effect upon the passions. Now, this is precisely what the average criminal nature most needs. The criminal is essentially a man who does not naturally act in unison or harmony with his fellow-men—he is prone to strike discordant notes—that is, to perform irregular and lawless actions. This disposition is probably due in part to distrust of himself, arising from a secret consciousness of deficiency. To such a man, a well-directed course of bodily exercise means, in the first place, the development of his physical organs and faculties; in the second place, a certain sense of power resulting therefrom; thirdly, a heightened self-respect and self-confidence; fourthly, a sense of the value of method; fifthly, a more regular flow of thought to more definite objects; and, sixthly, a certain development of the social instinct arising from a generally improved bodily and intellectual condition.

It may be accepted as a general principle that when a given result proves very difficult if not impossible of attainment we are trying to take *too big a step* to get at it—that is, we are overlooking some intermediate stage or stages that have to be passed through before we can get at our objective point. It is as if we wanted to get up-stairs all at once, instead of proceeding step by step. Well, in regard to criminals, we have preached at them in the effort to reach their spiritual nature; we have set the schoolmaster on them, in the effort to rouse their dormant intellectual faculties; now, at length, after abundant evidence as to how little either chaplain or schoolmaster can effect, we are trying what the drill-master can do to mend their crooked bodies, to reform their shambling gait, to fix the vacant or wandering eye, to infuse life, vigor, and "snap" into spiritless frames; and at last it seems as if we were on the right track. After all, what did St. Paul tell us long ago? "First that which is natural" (physical), "then that which is spiritual." Well, without heeding him any more than the ancient Greeks, who, in this matter at least, were so wise, we have in the main been working, or trying to work, on the spiritual, and leaving the natural to shift for itself, even when its defects have been most conspicuous, and when, owing to these defects, the spiritual has been almost non-existent. It is time to go back on our tracks and to see to it that we make things as

right as we can in the natural region, before we look for intellectual results or the peaceable fruits of righteousness. We seem already to see Science, the despised Cinderella, as Huxley says, scoring another triumph, and showing that, even for moral reform, its methods are worth more than all other modes of activity put together.

LITERARY NOTICES.

THE PROBLEM OF EVIL. AN INTRODUCTION TO THE PRACTICAL SCIENCES. By DANIEL GREENLEAF THOMPSON, author of "A System of Psychology." London: Longmans, Green & Co. 1887. Cloth. 8vo. Pp. 281.

"THE Problem of Evil," though modestly heralded by its author as "An Introduction to the Practical Sciences," and not assuming to present a complete exposition of ethical science, is in reality a noteworthy contribution to that department of philosophical inquiry. Aiming to clear the way for a popular understanding of the scientific method as applied to moral and social problems, Mr. Thompson's treatment of his topic is less technical and systematic than readers of "A System of Psychology" would naturally be led to expect. The present work, however, loses little, if anything, in value to the philosophical student on this account, while its more popular style, and the practical nature of many of the questions herein discussed, will doubtless render it more attractive to the general reader, and introduce its author to many new acquaintances among thinking people.

The question presented in the earlier chapters of this book, and ably discussed in all its various phases throughout the succeeding pages, is none other than the great problem of all the theologies and moral philosophies: How shall we interpret the startling but undeniable fact of moral evil? How may we most wisely strive for its abatement and cure?

After briefly and fairly stating the chief theological explanations of evil—"those which look to a supernatural source and cause"—and expressing his dissent from this method of approaching the subject, our author proceeds to define moral evil as "pain caused by human volition" (p. 17); and to investigate briefly its causes and offices in the human economy. "Pain," he concludes, "is a universal concomitant of mind, so far as we are able to make mind a subject of science." As we are unable to trace, scientifically, the origin of mind or life, we are therefore baffled in our attempt to disclose the ultimate origin of evil. The practical problem, accordingly, to which we should turn our attention is, How may we seek for its elimination by the most effectual means? In other words, How may we best strive for the advancement of human happiness?

Readers of "A System of Psychology" will be prepared to find our author in accord with utilitarian theories of ethics. The psychological and philosophical elements involved in the problem of evil, however, are assumed, or briefly sketched, rather than presented in the form of a complete argumentative exposition, in the present work—the philosophical foundations of this study having been laid by the author in the work before mentioned. From the standpoint of a rational utilitarianism, he criticises with great acuteness and force what he terms the "Æstho-Egoistic" philosophy of Thomas Hill Green, and other representatives of the intuitional school. In the "subjective feeling or consciousness of self-satisfaction," which expresses the *summum bonum* of intuitional ethics, he discovers an ideal which is essentially egoistic. His own interpretation of utilitarian ethics, on the other hand, issues in an altruism which is widely removed from the alleged "selfishness" of the hedonistic philosophers. The "Chief Ideal Good" being "the existence of all individuals without pain, presentative or representative, during this period of existence," right conduct is that which tends toward this ideal, and right volition is the will to act according to its requirements (p. 71).

The four chief methods of reducing evil are found to be—1. "The Control of Material Forces," through industrial effort and scientific discovery and investigation; 2. "Security and Justice," through political action; 3. "Direct Altruistic Effort"; and, 4. "The Development of Individual Character," through education and moral training. The chief hindrances to this work are—1. The

artificial morality of supernatural theology; 2. The unwarranted elevation of institutions above the individual; 3. The notion that social ends are more perfectly realized through the concentration of power in organizations; and, finally, the formation and retention of egoistic ideals of life.

In the section on "The Great Theological Superstition," Mr. Thompson criticises unsparingly, but in no dogmatic tone, the theological doctrine of sin. The idea that there can be a sin against God other than a violation of the rights and happiness of individual men, is found to be untrue, immoral in its implications and results—one of the chief obstacles, indeed, to human progress. Man's "sin against God, if it exist, is in his sin against his fellows"; in other words, theological sin, *per se*, is a fiction of the imagination; the only reality which can answer in any way to this conception is natural moral evil. Incidentally Mr. Thompson condemns the laws against blasphemy, the exercise of temporal power by the Church, the Pharisaical self-righteousness which he conceives to be the outcome of theological supernaturalism, the "baleful dogma" of eternal punishment, and the mystical conception of "spirituality," as something other than simple goodness, stimulating men to altruistic endeavor.

In the section on "The Institutional Fetich," a rational individualism is maintained as a higher ethical ideal than that which sinks the individual in the mass, and emphasizes institutions at the expense of personal liberties. "Man is the measure of all things." Institutions are made for man, not man for institutions. Authority must give way to the right of private judgment. The doctrine that "the family, the state, the Church, exist superior to any considerations of utility," must be condemned as inimical to the highest development of human character, and as an obstacle to the moral advancement of the race. The principle of authority in the family has resulted in the degradation of woman and the ignoring of the rights of children. "The husband owes to the wife just as many duties as she to him." "Children are to be worked for as human beings having their own independent ends, which are to be respected." "The doctrine of authority has been from the beginning, and is to-day, a stumbling-block in the way of woman's liberty and advancement."—These sentences strike the key-note of Mr. Thompson's liberal and humane treatment of these important social problems, which we can only thus briefly outline within the limits of this review. The divine authority and perfect character of the state is of course condemned as an irrational dogma. The right to agitate against an existing social order is strenuously affirmed. "Any system which does not permit the title of a governing power to be questioned by the governed, in the light of what is best for the general happiness, is a system of rule by force and fear, disguise it as you may under high-sounding phrases, as 'inherent sacredness,' or 'divine authority.'"

Under the head of "The Socialistic Fallacy," the questions of the "Co-operative Idea," "Socialism," "The Political Party," "Industrial Co-operation," are treated with great clearness and in an admirable spirit, as the reader will agree, even if he does not find himself wholly in accord with our author's conclusions. He cries "Halt!" to the active socialistic tendencies of our time, believing that they must ultimate, if successful, in an increase of egoism and restriction of individual liberty, which would be fatal to the highest ethical advancement of the race. Not in individualism, but in egoism, he affirms, is to be found the most serious obstacle to our moral progress.

Finally, the root of existing moral evil is found in the continued elevation of the egoistic ideal as an incentive to human action. War and the militant system are condemned as outgrowths and perpetuators of this ideal. The injustices and immoralities of our industrial system are referred to the predominance of egoism in our industrial methods; and the relief for all these social evils is indicated in the two rules:

1. "Aim at the minimum of extrinsic restraint, and the maximum of liberty for the individual."

2. "Aim at the most complete and universal development of the altruistic character."

While Mr. Thompson is in general accord with the English utilitarian school of philosophy, he is evidently an independent and original thinker—no mere servile fol-

lower of sect or leader. In many respects his conclusions agree with those of Mr. Herbert Spencer; but he is no imitator of Mr. Spencer's style, and he does not hesitate to express a frank disagreement with his opinions upon occasion—as in the matter of state education, which Mr. Thompson advocates, while Mr. Spencer condemns. A multitude of the pressing problems of our social life are suggested and discussed in this compact volume, with such frankness, sincerity, ability, and good feeling, that we can heartily commend it not only to the professional scholar, but to all thoughtful men and women. The interest which it will awaken will doubtless bespeak far Mr. Thompson's larger work—"A System of Psychology"—a wider circle of readers than it has hitherto had in this country.

THE FACTORS OF ORGANIC EVOLUTION. By HERBERT SPENCER. New York: D. Appleton & Co. Pp. 76.

THE two parts of which this essay consists were originally published in successive numbers of "The Nineteenth Century," and also of "The Popular Science Monthly." They are now given in a single volume, together with some passages of considerable length which were omitted, for the sake of brevity, from the magazine publication. Mr. Spencer believes that though mental phenomena of many kinds are explicable only as resulting from the natural selection of favorable variations there are others, still more numerous, which can not be explained otherwise than as the results of the inheritance of functionally-produced modifications. Not only the conceptions we form of the genesis and nature of our higher emotions and moral intuitions, but our sociological beliefs, are profoundly affected by the conclusions we draw on this point. "If a nation is modified *en masse* by transmission of the effects produced on the natures of its members by those modes of activity which its institutions and circumstances involve, then we must infer that such institutions and circumstances mold its members far more rapidly and comprehensively than they can do if the sole cause of adaptation to them is the more frequent survival of individuals who happen to have varied in favorable ways." Considering the effects which the acceptance of one or other of these hypotheses must have on our views, life, mind, morals, and politics, the question which of them is true, Mr. Spencer adds, "demands, beyond all other questions whatever, the attention of scientific men."

THE RULING PRINCIPLE OF METHOD APPLIED TO EDUCATION. By ANTONIO ROSMINI SERBATI. Translated by Mrs. William Grey. Boston: D. C. Heath & Co. Pp. 363. Price, $1.50.

ROSMINI proposed to apply to education the principles which were independently worked out by Froebel into the Kindergarten—the principles, as the translator describes them, on which Nature herself works. He contemplated a complete treatise on pedagogy, to be worked out in departments corresponding with the several stages of the unfolding and building up of the pupil's mind, having in view, however, not only the child at school, but, to use the words of Francesco Paoli, "the adult and the old, the whole race, in short, because in the man, at every stage of life, there is something of the child; there is a new development going on within him, which requires to be guided and assisted that it may reach a successful issue, and the man learn to educate himself." With this view, he divided his subjects into periods computed by the degrees of cognition which the human mind successively attains in its intellectual development. The first of these periods begins at birth, and includes about six weeks, during which no definite cognitions can be assigned to the child, except that primary and fundamental one of being; the second begins with the first smile and tears, with the simple perception of things as subsisting constituting its cognitions, to which correspond the volitions, which have these things as their object. The third period is marked by the acquisition of speech, which shows that the child has attained the power of analysis and abstraction, with volitions having sensible qualities as their object. The fourth period shows itself in the aptitude to learn to read, and is characterized by the exercise of the faculties of judgment and comparison, and by the development of the moral sense, which was already existing in the germ. Thence are developed conscience, synthetic cognitions, and the free use of the

reason. The executed work of Rosmini was terminated at this period; but he left notes from which it appears that he had intended to treat of four other periods, each marked by the development or perfecting of its peculiar faculties. We miss much by not having the completion of a work so well planned, but, "fortunately, the earlier part, which is preserved to us, contains the fundamental principles both of method and practice, which remain the same for all periods of life, and of which only the application varies with the varying degrees of individual development."

TEXT-BOOK OF ZOÖLOGY; FOR JUNIOR STUDENTS. By HENRY A. NICHOLSON, Regius Professor of Natural History in the University of Aberdeen. Fourth edition. New York: D. Appleton & Co. Pp. 388. Price, $1.60.

PROFESSOR NICHOLSON introduces the study of animals by some general considerations of the scope of zoölogy, the conditions of life, classification, and the distribution of animals in space and in time. The present edition of the work has been thoroughly revised and brought up to the present standard of zoölogical knowledge. Recent additions to our acquaintance with the existing or extinct fauna of the world have been noticed in the text, and some fresh illustrations have been added. The scope of the work does not allow space for long descriptions of extinct animals, but those whose characteristics throw light on the relations of living species are briefly described. The definitions of important divisions are printed in italics, and the book is copiously illustrated. A glossary and an index are appended.

WATSON'S PHONOGRAPHIC INSTRUCTOR. By JOHN WATSON. New York and London: G. P. Putnam's Sons. Pp. 144.

THE chief peculiarities in the method of teaching Pitman's phonography, which is embodied in this manual, are that vowel-placing and reading are postponed until considerable speed has been attained in writing the consonant outlines of words. When this point has been reached, the author claims that the pupil has become so well acquainted with word-forms that he can read the bulk of his writing without vowels. The pupil is then taught to place a vowel-mark here and there where it will do the most good, until he learns to use as many vowels as a reporter must use. Ability to read comes almost insensibly. A key to exercises occupies twenty-four pages of the volume, and several other pages are devoted to model outlines, contractions, and select phrases, but the author deems reading-lessons useless.

RAILWAY PRACTICE: ITS PRINCIPLES AND SUGGESTED REFORMS REVIEWED. By E. PORTER ALEXANDER. Pp. 60. Price, 75 cents. THE INTERSTATE COMMERCE ACT: AN ANALYSIS OF ITS PROVISIONS. By JOHN R. DOS PASSOS. New York: G. P. Putnam's Sons. Pp. 125. Price, $1.25.

BOTH of these books belong to the "Questions of the Day" series. The essay of Mr. Alexander appears to have been prepared with especial reference to Mr. T. F. Hudson's book and the articles of Mr. Ely on railroad questions, and to the Reagan bill. The three solutions offered by these persons disagreeing radically in principle, and being also at odds with the methods of reform which the railway-managers themselves have instituted, there is some confusion in the premises from which the different parties start. The author's effort is to find means for removing the confusion. There must be a few principles at least settled by actual test and put beyond question or dispute to constitute what we might call the present state of the science of railway management. He therefore takes up the most important questions of railway management, and examines them in the light of those principles. Mr. Dos Passos gives in his book a systematic and detailed analysis of the provisions of the Interstate Commerce Act, preceded by a history of legislation on the subject, and supplemented by the text of the act itself. His exposition is as lucid as the law, which is far from being free from obscurities, will permit a commentator to make it.

A NEW BASIS FOR CHEMISTRY: A CHEMICAL PHILOSOPHY. By THOMAS STERRY HUNT, M. A., LL. D. (Cantab.). Boston: Samuel E. Cassino. Pp. 165.

FROM time to time since 1848 the author has been publishing portions of a theory of

chemistry, designed to fill more perfectly the place occupied by the atomic hypothesis. The solution of one problem, namely, that of the relation of equivalent weight to specific gravity in liquids and solids, which was necessary to a complete chemical philosophy, was wanting till 1886, so that in the present volume the author first presents as a whole his new basis for chemistry. The several parts of the theory are set forth largely in quotations from the author's earlier writings. Professor Hunt agrees in the belief that such matter as forms the substances called elements on the earth exists in stars and nebulæ in a still more elementary and tenuous form. From this primary matter he deems all known substances to be formed by greater or less degrees of condensation. He regards chemical combination as an interpenetration of masses, by which "the uniting bodies come to occupy the same space at the same time," and names solution as the type of such union. What we are accustomed to call the liquid and solid states of a substance, he regards as polymers of the corresponding vapor, whose equivalent weights are as much higher as their densities are greater than that of the vapor. He deems the atomic theory unnecessary for explaining the law of definite proportions, and, from its making combination consist in juxtaposition, untenable. His views are supported by his studies in mineralogy, which have shown that the hardness of isomeric species and their indifference to chemical reagents increase with their condensation.

BRAZIL, ITS CONDITION AND PROSPECTS. By C. C. ANDREWS. New York: D. Appleton & Co. Pp. 352. Price, $1.50.

BRAZIL, the only other country on the Western Continent approaching our own in extent, and with 13,000,000 inhabitants, is to us well worth knowing. Yet there are few people in the United States to whom the information in this volume would not have the charm of novelty. The author gained his acquaintance with Brazilian affairs and customs during a residence of three years in Rio Janeiro as United States consul-general. His pages teem with facts in regard to routes of travel, houses, markets, conveyances, religion, business customs, the emperor, special localities, climate, foreign commerce, education, government, literature, agriculture, animals, slavery, immigration, and a host of other topics. The impression which the book conveys is that Brazil is not an especially desirable country for an American to emigrate to. It is difficult for a stranger to procure desirable lands for agriculture or stock-raising, and foreigners who attempt professional careers must struggle with jealousy and suspicion, besides formidable competition. The seclusion of young women seems to be still practiced with almost Oriental strictness on the plantations, as witness the following extract:

> Presently the senhora reappeared, leading one very modest looking damsel of about eighteen or nineteen years of age, and closely followed by three others, apparently somewhat younger. All appeared to be overwhelmed with intense shyness, and an almost hysterical desire to laugh. After a formal and separate introduction of each one—be it noted that the lady was here introduced to the gentleman—they all retired back again into the secret chamber, and their papa once more turned the key upon them. At this time we were ignorant of the custom, which I afterward found to be so general in these out-of-the-way parts, of keeping the women, or rather the daughters of the family, locked up like wild beasts.

CONTROLLING SEX IN GENERATION. By SAMUEL H. TERRY. Second edition. With an Appendix of Corroborative Proofs. New York: Fowler & Wells Company. Pp. 209.

IN order to more fully corroborate the views advanced in the body of this work, the author has added in this edition an appendix, consisting of extracts from "The Popular Science Monthly" and other periodicals, letters from cattle-breeders, etc., and a chapter in answer to objections.

THE CREMATION OF THE DEAD. By HUGO ERICHSEN, M. D., with an Introductory Note by Sir T. Spencer Wells. Detroit: D. O. Haynes & Co. Pp. 264. Price, $2.

IN this book the subject is considered from the æsthetic, sanitary, religious, historical, medico-legal, and economical points of view. The author is a warm advocate of cremation, and closes with a prediction that it will make more progress in the United States than in any other country of the world. The text is illustrated with several views and plans of crematoriums, urns, etc.

A JUNIOR COURSE OF PRACTICAL ZOÖLOGY. By A. MILNES MARSHALL, M. D., F. R. S., assisted by C. HERBERT HURST. London: Smith, Elder & Co. For sale by G. P. Putnam's Sons, New York. Pp. xxiv–440.

THIS book is a laboratory manual designed as a guide to a practical acquaintance with the elements of animal morphology. In almost all cases the descriptions of animals are so arranged that the whole dissection can be performed on a single specimen. Strict uniformity of treatment has not been specially aimed at; thus the more difficult portions of the subject are treated at considerable length, while systems of subordinate educational value, such as the muscular, occupy little space. Few illustrations have been introduced lest the student should give too little attention to the drawings which he must make from his own dissections. The animals selected for description are amœba, and three other protozoa, hydra, liver-fluke, leech, earthworm, fresh-water mussel, edible snail, crayfish, cockroach, lancelet, dog-fish, rabbit, fowl, and pigeon.

SANITARY EXAMINATIONS OF WATER, AIR, AND FOOD. By CORNELIUS B. FOX, M. D., F. R. C. P., London. With 110 Illustrations. Second edition. Philadelphia: P. Blakiston, Son & Co. Pp. 563. Price, $4.

THE reliability of Dr. Fox's sanitary work led to the expansion of his pamphlet on "Water Analysis" into a volume containing sections on examinations of air and food, in 1878, and has now brought this volume to a second edition. The chief new features of this edition are the extension of water and air examination in the direction of those biological methods that have been introduced of late years, and that are deemed by German and French sanitarians as important as the chemical analysis. Recently devised improvements in the examination of milk are also recorded.

DUE NORTH: OR GLIMPSES OF SCANDINAVIA AND RUSSIA. By MATURIN M. BALLOU. Boston: Ticknor & Co. Pp. 373.

THE author visited Copenhagen and Elsinore, in Denmark, traveled over much of Sweden and Norway, saw the midnight sun, had a glimpse of Finland, visited St. Petersburg, Moscow, and Nijni-Novgorod, and spent a few days in Poland. His sketches of all these parts include accounts of scenery, buildings, people, customs, sites having historical interest or interesting by personal association, and observations on moral, social, political, and religious conditions. His view of the Czar and his government is decidedly more favorable than those which we are accustomed to hear expressed.

THE TRUE DOCTRINE OF ORBITS: AN ORIGINAL TREATISE ON CENTRAL FORCES. By H. G. RUSH, of New Danville, Pennsylvania. Pp. 133.

THE author endeavors, by mathematical demonstrations, to prove that the orbits of the planets, and even of the comets, are not elliptical, as the Newtonian astronomy supposes, but circular.

REPORT OF THE PROCEEDINGS OF THE AMERICAN HISTORICAL ASSOCIATION. Third Annual Meeting, April 27–29, 1886. HERBERT B. ADAMS, Secretary. New York: G. P. Putnam's Sons. Pp. 104. Price, $1.

THE membership of the Association has grown since its organization in September, 1884, from forty to four hundred and twenty-two members, seventy-eight of whom are life-members. The third meeting was held in Washington, and the discussions included such topics as the capture of Washington in 1814, and the campaigns of our late war, besides many others of a more general character, and some bearing upon what used to be called the philosophy of history. Among the achievements claimed for this meeting are the friendly reunion of military historians from the North and from the South; the peaceful discussion of the campaigns before Washington, and in the Valley of Virginia; the historical representation of the new South and the Northwest, as well as of the Northern States and Canada; the treatment of almost every branch of our American history; the meeting of the youngest historians with the very oldest—Mr. Bancroft; the mingling of representatives from various historical schools; and the presence of Congressmen and visitors from different parts of the Union. "It was a veritable national convention, in the political center of the United States, for the furtherance of American history and of history in America."

PUBLICATIONS RECEIVED.

Henderson, C. Hanford. Philadelphia. Notes on the Modifications of the Bessemer Steel Process. Pp. 9.

Miles, Manly, Lansing, Mich. The Microbes of Nitrification.

"The Ottawa Naturalist," June, 1887, Ottawa, Canada. Pp. 16. $1 a year.

"Civics." Vol. I, No. 1. June, 1887. Quarterly. Pp. 56. $1 a year.

Stoney, Wilbur L., Goshen, Ind. The Circulation of the Blood: A Theory. Pp. 3.

Outerbridge, A. E., Jr. A New Process of casting Iron and other Metals upon Lace, Embroideries, Fern-Leaves, and other Combustible Materials. Pp. 4.

New York Ladies' Health Protective Association. Memorial to Mayor Hewitt on Street-Cleaning. Pp. 12. Memorial on Slaughter-Houses. Pp. 7.

Cooper Union. Twenty-sixth, Twenty-seventh, and Twenty-eighth Annual Reports of the Trustees. Pp. 44.

Oliver, Charles A., M. D. A New Series of Berlin Wools for Color-Blindness Tests. Pp 41. A New Series of Metric Test Letters and Words for Accommodation-Tests. Pp. 1.

Groh, Israel W. Is the God of Israel the True God? New York: Truth-Seeker Company. Pp. 79.

Bell, Clark. Seventh Inaugural Address as President of the Medico-Legal Society of New York. Pp. 13. Insanity and the Care of the Insane Pp. 48

Foerste, A. F., Denison University. "Flint Ridge" Bryozoa. Pp. 18, with Plate.

Allen Gymnasium, Boston. Circulars for 1886 and 1887.

Hubbell, Alvin A., M. D., Buffalo, N. Y. Congenital Occlusion of the Posterior Nares. Pp. 16.

West, James H. The Work of a True Church. Chicago. Pp. 14.

Bell, A. N., M. D. The Physiological Conditions and Sanitary Requirements of School-Houses and School-Life. New York: Medical Society of the State of New York. Pp. 88.

Romero, Señor Don Matías. Speech on the Birthday of General U. S. Grant. Pp. 16.

Campbell, M. M., Topeka, Kansas. Open Letter No. 1 and Open Letter No. 2. To American Rulers, and to all who write or read American Literature.

"The Woman's Argosy," June, 1887. Monthly. Chicago and New York. Pp. 64, with Plates. $3 a year.

Davis, W. M., Cambridge, Mass. Water-Vapor and Radiation. The Foehn in the Andes; and other Meteorological Papers.

Upton, Winslow, Providence, R. I. An Investigation of Cyclonic Phenomena in New England. Pp. 54.

Nimmo, Joseph Jr., Huntington, L. I The Interstate Commerce Act, Third and Fourth Sections. Pp. 8.

Woman's Medical College of the New York Infirmary. Nineteenth Annual Catalogue and Announcement. Pp. 19.

Ohio State University, School of Agriculture and Veterinary Medicine, 1886-'87.

Ohio Agricultural Experiment Station, Columbus. Report for 1886. Pp. 316.

Peabody Museum of American Archæology and Ethnology, Cambridge, Mass. Twentieth Annual Report of the Trustees. Pp. 84.

Putnam, F. W. Conventionalism in Ancient American Art. Pp. 12, with Plates.

Rotch, A. Lawrence. Results of Meteorological Observations at Blue Hill Observatory, Mass. Pp. 45, with Plates.

"Social Science." Vol. I, No. 1. Weekly. New York. Pp. 16. $3 a year.

Queen, James W., & Co., Philadelphia. "Microscopical Bulletin and Science News," Edward Pennock, Editor. Monthly. Pp. 16. 25 cents a year.

Eggleston, E. R., Mount Vernon, Ohio. Malaria: Its Origin and Cause as a Factor in the Production of Disease. Pp. 8.

Indiana Signal Service, H. A. Huston, Purdue University, Lafayette, Director. "Bulletin" for May, 1887. Pp. 8.

Austen, Peter T., Ph. D., Rutgers College, New Brunswick, N. J. The Study of Analytical Chemistry. Address to Class of '86, Rutgers Grammar-School. Pp. 8.

Buller, Nicholas Murray, Ph. D. The Effect of the War of 1812 upon the Consolidation of the Union. Baltimore: Johns Hopkins University. Pp. 30. 25 cents.

"The American Weekly," San Francisco. Pp. 16. 10 cents, $3 a year.

Vasey, George. Grasses of the South. Washington: Government Printing-Office. Pp. 63.

Pohlman, Julius, Buffalo, N. Y. The Niagara Gorge. Pp. 2. The Human Teeth viewed in the Light of Evolution. Pp. 6.

Engelmann, George J., M. D., St. Louis. The Use of Electricity in Gynecological Practice. Pp. 149. Galvanic and Faradic Electricity in the Treatment of Uterine Displacements. Pp. 30.

Board of Education, Rochester, N. Y. Thirty-ninth Annual Report. Pp. 189.

Kneass, Philadelphia. "Magazine for the Blind." May, 1887. Pp. 16. 30 cents, $3.50 a year.

Moury, William A., Editor. "Common-School Education Monthly," Boston, Eastern Educational Bureau. Pp. 40. 15 cents, $1 a year

"Medical Classics." Vol. I, No. 1. June, 1887. Medical Classics Company, New York. Pp. 16.

"American Journal of the Medical Sciences," I. M. Hays, Philadelphia, and Malcolm Morris, London, Editors Quarterly. Philadelphia: Lea Brothers & Co. Pp. 304. $5 a year.

Lewis, T. H., St. Paul, Minn. Snake and Snake-like Mounds in Minnesota. Pp. 3.

"Home Knowledge," Robert A. Gunn, Editor. June, 1887. New York: Home-Knowledge Association. Pp. 64. 20 cents, $2 a year.

Tidy, Dr. C. Meymott The Treatment of Sewage New York: D. Van Nostrand. Pp. 224. 50 cents.

Johnson, Virginia W. The House of the Musician. Boston: Ticknor & Co. Pp. 286. 50 cents.

Wiley, John, & Sons, New York. Practical Works and Text-Books on Civil, Mechanical, Mining, and Marine Engineering, etc. Catalogue and Descriptions. Pp. 175.

Wellcome, Henry S. The Story of Metlakahtla. New York: Saxon & Co. Pp. 483. $1.50.

Heermans, Forbes. Thirteen Stories of the Far West. Syracuse, N. Y.: C. W. Bardeen. Pp. 268.

Brown, John Allen. Paleolithic Man in Northwestern Middlesex. London: Macmillan & Co. Pp. 204, with Plates.

Greenwood, J. M. Principles of Education Practically Applied. New York: D. Appleton & Co. Pp. 192. $1.

White, James C., M. D. Dermatitis Venenata. Action of External Irritants upon the Skin. Boston: Cupples & Hurd. Pp. 216.

Hubbard, Bela. Memorials of a Half-Century. New York: G. P. Putnam's Sons. Pp. 581, with Plates.

Smithsonian Institution. Annual Report of the Board of Regents to July, 1885. Part I. Washington: Government Printing-Office. Pp. 996.

Powell, J. W., Director. Fourth Annual Report of the Bureau of Ethnology—1882-'83. Washington: Government Printing-Office. Pp. 592.

POPULAR MISCELLANY.

Report upon the Charleston Earthquake.—The United States Geological Survey, according to a communication from Messrs. Dutton and Hayden in "Science," has received reports relating to the Charleston earthquake from more than sixteen hundred localities, giving a much larger amount of information than has ever before been collected concerning any one earthquake. A considerable proportion of the reports were in answer to a printed list of questions which had been sent out, to direct attention to the most distinct and significant features of the phenomena. The first point to receive attention is the magnitude of the area affected by the shocks. The earthquake was felt in Boston, near Lake George, and at two points in the Adirondacks, at several places in Ontario, Michigan, and Wisconsin (at La Crosse, nine hundred and sixty-seven miles from Charleston, the most remote point within the United States which has given a positive report), in some of the Florida Keys, in Cuba, and in Bermuda, a thousand miles from Charleston. The area within which the shakings were marked enough to attract considerable attention, would be somewhat more than circumscribed by a circle of a thousand miles radius. The movement might, however, have been detected, by instrumental observation, over a much greater area. There are some large tracts within the area which show comparatively feeble intensity. The most conspicuous of them is the Appalachian region. This fact is of interest in its bearing on the supposition that mountain-ranges serve as barriers to the propagation of earthquakes. Another minimum area was in Indiana and Illinois; and it nearly corresponded with the area in which a considerable earthquake occurred on the 6th of February. The coincidence is curious, if not significant. At nearly all places within about two hundred and fifty miles of the center the energy of the shock was very great. Coming nearer to the center, the intensity increased on all sides, with differences in kind as well as in degree. "The phenomena characteristic of the epicentral area cease with something like abruptness as we radiate away from the epicentrum. The central phenomena are those produced by shocks in which the principal component of the motion of the earth is vertical. Proceeding outward, these predominating vertical motions pass, by a very rapid transition, into movements of which the horizontal component is the greater, and in which the undulatory motion becomes pronounced." The rapidity of these transitions, or the shape of the intensity-curve into which they may be translated, is supposed to be dependent upon the total energy and depth below the surface of the shock. The distance from the epicenter to the point where the rate of decline of the intensity is greatest, is simply proportional to the depth of the focus, and is the same whether the energy be greater or less. This gives a rule for estimating the depth of the focus. Applying the rule, we have a computed depth of twelve miles, with a probable error of one or two miles, for the focus of the principal shock at Charleston. There is reason for beliving that none of the great earthquakes of the last one hundred and fifty years have originated from a much greater, and few from as great, a depth. The city of Charleston was situated at from eight to ten miles outside of the area of maximum intensity. Had the seismic center been ten miles nearer to it, the calamity would have been incomparably greater than it was. The shocks were also probably made easier for the city by the loose nature of the soil and quicksands over which it is built. The time-data have not been fully worked out, but it is thought that they will give a speed of propagation exceeding three miles a second—a rate which "will probably prove unexpected to European seismologists."

Some Popular Errors about the Eskimos.—Mr. John Murdoch has exposed, in the "American Naturalist," a few popular errors in regard to the Eskimos, some of which have found their way into Hovelaque and Hervé's recent book on "Anthropology." Polyandry is not common among them, as is asserted there and by Bancroft, but is very rare, if it exists noticeably at all. Eskimo houses are seldom, if ever, holes dug in the earth, as the French authors say, but wooden, turf-covered lodges, built sometimes over an excavation of only moderate depth,

as often wholly upon the surface, or else, farther north, they are the well-known snow-house. The people do not live a torpid existence in winter, but an extremely busy and active one, in employments which call out the energies, in some shape or another, of the whole family. The eating of raw flesh, which has been attributed to this people, is exceptional and usually practiced only under stress. The enormous consumption of fat, also, "supposed to be a physiological necessity to enable them to withstand the excessive cold, is probably the exception rather than the rule, to judge from the accounts of actual observers. It seems quite probable that the amount consumed in most cases is little, if any, greater than that eaten by civilized nations, when we consider that the people who eat the fat of the seal with the flesh, and use oil for a sauce to their dried salmon, have no butter, cream, fat bacon, olive-oil, or lard." The French authors correct one popular error in regard to the relative stature of the Eskimos, and declare that they are but little below the medium stature, having an average height of about five feet three inches, while "medium stature," according to Topinard, in five feet four inches. In comparing several series of measurements of Eskimos, only one was found that at all corroborates the popular opinion of their small size, and that gave the average height of twenty-three men at Cumberland Gulf as five feet 2·4 inches, still above Topinard's standard of small stature (five feet one and a half inch or less).

The Coming Solar Eclipse.—The total eclipse of the sun of August 19th will occur under circumstances offering unusual facilities for concurrent observation. The line of totality crosses Asia and Europe from Japan to the British Islands, and the phenomenon can be observed with the sun at a good height from all places on this line east of Moscow. Among these points are Tver, Petrovsk, Kineshma, Perm, Tobolsk, Tomsk, Krasnoyarsk, Irkutsk, and several stations in Japan, where the opportunities for observing will be even better than in Russia and Siberia. Professor C. A. Young will have a station at Tver, and parties of English and Italian astronomers will observe in the neighborhood. As nearly all the points in Russia and Siberia are connected by telegraph, the observing parties will have facilities for instantaneous communication with one another.

Disposal of Sewage and Garbage.—Mr. W. Howard White has given to the American Society of Civil Engineers his views as to the comparative value and feasibility of five different methods of disposing of sewage and garbage. The method of dry removal is still in most general use, and costs, in Leeds, England, including removal of ashes and garbage, twenty-four cents per head a year. The great defect of removal by water-carriage, such as prevails in all large cities, is that usually it only takes the nuisance to another place, without abating it. This fact, and the failure of the currents depended upon to carry the stuff far enough away, have led to the introduction of the method of water-carriage with works for purification by precipitation. This is effected at the Knostrop Works, Leeds, by means of a set of settling-basins, with milk of lime as the precipitant. At Frankfort, alumina ferric is to be used. The method of water-carriage, with filtration or irrigation, can be applied with great advantage in small towns; but in cities of more than one hundred thousand inhabitants it is met by the difficulty of getting enough land to make the effectual application of filtration or irrigation practicable. The method of dry removal and making up into salable products is practiced on a large scale at Manchester, England. Urine and fæces partially deodorized with the house-ashes are converted into manure and a variety of useful compounds at a cost of from twenty-four to thirty-seven cents per head a year. The Liernur separate pneumatic system is judged to be more expensive than any other well-arranged method. In some places in England and in Holland, refuse not suitable for the sewers is burned in destructors at small cost. At Leeds, the stuff is fed at the top of the apparatus, and works down gradually to the grate, where fire once started is kept up by the refuse itself. Dr. C. Meymott Tidy says that no single answer can be given to the question of the disposal of sewage. The adviser must sink his hobby and

be prepared to find conditions under which he would counsel irrigation, and other conditions under which he would recommend precipitation. Success at one place furnishes no argument that a process will be successful everywhere. His own experience of all kinds of schemes has led him to prefer a scheme combining the principles of precipitation and irrigation. It has the advantages that its efficient working is independent of the weather; and that, if the works are sufficiently large, any emergency of quantity can be met.

Atlantic and Pacific Fishes.—Professor David S. Jordan has published, in the "Proceedings of the United States National Museum," a list of the fishes known off the Pacific coast of America, from the Tropic of Cancer to Panama. Our knowledge of these species is due chiefly to the studies of Dr. Gill, Dr. Günther, Dr. Steidachner, and Professors Jordan and Gilbert; and the work of the few collectors who have given special attention to the subject has in nearly all cases been of exceptional value. Of the four hundred and seven species of fishes now known from the Pacific coast of Mexico and Central America, seventy-one species, or seventeen and a half per cent, are also found on the Atlantic coast. If we add to this some eight hundred species, now known, from the Caribbean Sea and adjacent shores, we have about six per cent of the whole number known as common to the two coasts. With only this proportion of common species, the two faunæ show no greater resemblances than the similarity of physical conditions on the two sides of the continent would lead us to expect. This conclusion is opposed to the views expressed by Dr. Günther in his "Fishes of Central America," where he assumes that nearly one third of the total number of species of marine fishes on the two shores of tropical America will be found to be identical. Hence he infers that there must have been, at a comparatively recent date, a depression of the isthmus, producing an intermingling of the two faunæ. The discrepancy arises from the comparatively limited representation of the two faunæ, at the disposal of Dr. Günther. Several of the identical species are pelagic fishes common to most warm seas. Others are almost cosmopolitan in the tropical waters; while most of the rest often ascend the rivers of the tropics. We may account for their diffusion, perhaps, as we account for the dispersion of fresh-water fishes on the isthmus, on the supposition that they may have crossed from marsh to marsh at some time in the rainy season. Professor Jordan is therefore brought to the conclusion that the fish fauna of the two shores of Central America are substantially distinct, so far as species are concerned, and that the resemblance between them is not so great as to necessitate the hypothesis of the recent existence of a channel across the isthmus.

Progress of Stellar Photography.—From a paper by Professor E. C. Pickering, on "An Investigation in Stellar Photography, conducted at the Harvard College Observatory," it appears that the first work in this branch was an experiment made at the observatory in July, 1850, when, under the direction of Professor W. C. Bond, a satisfactory image of the star α *Lyræ* was obtained by Mr. J. A. Whipple. Subsequently, the double star α *Geminorum* gave an elongated image, evidently due to its two components. Objects as bright as these gave but faint images, and no impression was obtained from the pole-star, however long the exposure continued. The experiment was repeated with various stars and clusters, but the work was finally abandoned, owing to the imperfections of the driving-clock and the lack of sensitiveness of the plates. Both of these difficulties were partially remedied in 1857; the research was resumed by Professor G. P. Bond, and the value of stellar photography as a means of determining the positions and brightness of the components of double stars was established. The present research was undertaken in 1882, when it was shown that photography could be used as a means of forming charts of large portions of the sky, and of determining the light and color of stars in all parts of the heavens. Photographs of the trails of polar stars no brighter than the eleventh magnitude were obtained without clock-work. Stellar spectra were obtained of the brighter stars without clock-work, in which all the principal lines

were well shown. The investigation having been resumed in 1885, with a larger telescope, one hundred and seventeen stars within 1° degree of the pole, each of them no brighter than the fourteenth magnitude, left trails. The average deviation of the measures of the brightness of these stars on different photographs was less than a tenth of a magnitude, a greater accordance than is given by any other photographic method. A similar result was obtained from the Pleiades, of which group more than fifty stars left trails. Trails are now being photographed of all the stars north of −30° in all right ascensions, and the work has been completed for more than half of the sky. By photographing on the same plate polar stars near their upper and lower culminations, material has been accumulated for determining the atmospheric absorption on each night of observation. A study has been made of the application of photography to the transit-instrument. By placing a large prism in front of the object-glass, excellent stellar spectra have been obtained. An exposure of five minutes gives the spectra of all stars brighter than the sixth magnitude within a region 10° square. About half of the region north of −25° has been photographed in this way. With an exposure of an hour, the spectra of stars no brighter than the ninth magnitude are shown. Over a hundred stars have thus been taken simultaneously on a plate by a single exposure. Miscellaneous observations have been secured of the Pleiades, of the nebula in Orion, of Jupiter's satellites, and of various other objects; also of the new star in Orion, and of its spectrum, and one plate showing that this star must have been much fainter on November 9, 1885, than when discovered five weeks later.

The Prospect for Silk-Culture in the United States.—Dr. C. V. Riley, of the Entomological Division of the Agricultural Bureau, said in the preface to the second edition of his "Manual of Silk-Culture," in 1882, that the elements of successful silk-culture on a large scale were entirely wanting in this country; that "the profits of silk-culture are always so small that extensive operations by organized bodies must prove unprofitable where capital finds so many more lucrative fields for employment; that extensive silk-raising is fraught with dangers that do not beset less ambitious operations, "and that silk-culture is to be recommended only as a light and pleasant employment for those members of the farmer's household who either can not do or are not engaged in otherwise remunerative work." In the latest edition of the "Manual" (1886) the author regrets that his original estimates, made in 1879, of the profitableness of the enterprise have been criticised because they had not been realized—the trade had, in fact, been passing through a period of depression; and he reiterates the caution that "silk-raising on an extensive scale is fraught with so many dangers, that it is inadvisable to invest capital in such an enterprise." Silk-culture, he says in another place, "is not (and it never has been) an exceedingly profitable business; but it adds vast wealth to the nations engaged in it, for the simple reason that it can be pursued by the humblest and poorest, and requires so little outlay. The question of its establishment in the United States is, as I have elsewhere said, a question of adding to our own productive resources. There are hundreds of thousands of families in the United States to-day who would be most willing to add a few dollars to their annual income, by giving light and easy employment for a few months each year to the more aged, to the young, and especially to the women of the family, who may have no other means of profitably employing their time."

Wood and Metal for Railroad-Ties.—M. Henri Mathieu, chief-engineer of the French railway *du Midi*, from observations on the consumption of the wood ties on French railways, has found that their duration depends upon several factors, among which are the material employed, the climate, the ground, and the ballasting. It principally depends upon the system of preparing the ties, and the quality of the antiseptic material; and the observations made on one line often differ from those made on another line. Averaging the results—oak ties, not prepared, last fourteen years; when creosoted, eighteen years. Creosoted beech ties last from eight to ten years; creosoted

ties of pines of the Landes, twelve years; prepared with sulphate of copper, from eight to twelve years. While, as between wood and the substitution of metal for it, M. Mathieu favors sticking to wood, he admits that the substitution of steel for iron is an important matter, and that one of the principal inconveniences of the metallic ties—want of solidity in the joints—may be obviated by careful attention during the first two years, which will make the rails and the sleepers solid. Metallic ties should be made heavier than they are, if they are to succeed. They had been laid, at the beginning of 1884, on 5,708 kilometres of lines in Germany, Austria, Holland, Belgium, and Switzerland.

Some Ancient Philosophy.—A book called "Speculum Mundi, or a Glass representing the Face of the World," published in 1670, gives a curious picture of what passed for science before the great modern discoveries were made. It consists of a chapter on each of the six days of creation. It says that the world was at first an unfashioned lump. Having disposed of the question of the firmament as best it could, it says of the air that the highest region is said to be "exceeding hot," because of the stars. Meteors and comets, it informs us, are "composed of Vapours or Fumes—a kinde of Smoak." Some of these vapors "transcend" very high, "even to the Starry Heaven itself; which is witnessed by our best Modern Astronomers, who have observed many Comets above the Moon." Great events are connected with comets, because those bodies consist of "many hot and dry Exhalations" and "distemper the Air," which "the Bellows of the Body suck in and receive; insomuch that there cannot but be Sickness, Plague, and much mortality." Moreover, these "poysonous breathings" are "very apt so to disorder and dry up the Blood in Humane Bodies, that thereby great store of red and a dust choler may be purchased; and this stirreth up to anger with the thought of many furious and violent actions, and so by consequence to war." Thunder is caused "by reason of Hot and Dry Exhalations shut within the cloud, which, seeking to get out, with great Violence do knock and rend the cloud." The hot and dry exhalation in escaping is set on fire by the violence, and becomes lightning, when it often continues burning until it falls to the ground. "And oftentimes a great stone is blown out of the cloud with it; whose cause is also natural." For, when the exhalation is drawn up from the earth, it sometimes takes earthy matter "like unto the finest sand" with it, and this, "through the moisture which it getteth in the Air," "clottereth together," and, "by the excessive heat which it findeth in the general matter of the exhalation," becomes hard like a brick. Sometimes the exhalations carry up also frogs, fishes, and grain, or the vehement heat of the sun draws milk, and we are treated to curious showers of corresponding nature. We are also informed that the long, streaming threads seen floating in the air, and vulgarly supposed to be spiders' webs, are nothing of the kind, but meteors, which "may rightly be supposed to proceed out of a through-boyled or digested vapour, being mixed with earthy and slimy Exhalations."

Tourist and Alpine Clubs.—A manual of the Tourist Unions of the world—under which designation are included Mountain and Alpine clubs and the like—published by Herr R. Koehler at Eisenach, shows that these associations, which are really of recent origin, have thriven greatly. The census of them gives a total of 78 clubs or unions, with 775 sections and 79,955 members. Of these, 73 clubs, with 770 sections and 79,365 members, are in Europe; four clubs, with 590 members, in America; and one club in Asia. The largest of them all is the German and Austrian Alpine Union, which has 109 sections and 12,274 members. Their special organizations and objects vary according to the characteristics of the nation in which they severally exist, but the common object of them all is the study, exploration, and enjoyment of natural scenery, with a prominent place given to mountain-climbing.

Artificial Rubies.—Mr. George F. Kunz recently read a paper before the New York Academy of Sciences on some artificial rubies that have been offered in the market of Paris as genuine rubies from a new locality.

On examination of specimens of the stones the author found their principal distinguishing characteristic to be the presence of spherical bubbles, rarely pear-shaped, or having stringy portions showing how they had moved, but with the ends always rounded, and presenting a cloudy appearance or an arrangement in wavy groups. In natural rubies the cavities are always angular or crystalline in outline, and are usually filled with liquid; or, sometimes they are arranged with the lines of growth, forming part of a feather, as it is called by jewelers. In many genuine rubies we find a silky structure which appears under the microscope to be a series of cuneiform or acicular crystals, usually iridescent. No traces of these have been found in the artificial specimens. The stones are about equally hard and of nearly equal specific gravity with genuine rubies. Their color is good, but not so brilliant as that of a very fine ruby. The syndicate of diamonds and precious stones of Paris has directed that all stones of this kind shall be marked artificial, else they will be considered fraudulent, and sellers of them will be dealt with accordingly.

NOTES.

THE retiring President of the American Association for the Advancement of Science, who will give the presidential address at the New York meeting, is Professor Edward S. Morse, of Salem, Massachusetts. He will review what American zoölogists have done to advance the doctrine of evolution. Professor S. P. Langley, of Washington, will enter upon the office of president at this meeting. The vice-presidents, who are to preside over the several sections, are: A. Mathematics and Astronomy, William Ferrel, of Washington; B. Physics, W. A. Anthony, of Ithaca, New York; C. Chemistry, Albert B. Prescott, of Ann Arbor, Michigan; D. Mechanical Science, Eckley B. Coxe, of Drifton, Pennsylvania; E. Geology and Geography, G K. Gilbert, of Washington; F. Biology, W. G. Farlow, of Cambridge, Massachusetts; H. Anthropology, D. G. Brinton, of Media, Pennsylvania; J. Economic Science and Statistics, Henry E. Alvord, of Amherst, Massachusetts.

THE American Public Health Association will hold its fifteenth annual meeting this year at Memphis, Tennessee, November 8th to 11th. The topics to be considered are: "The Pollution of Water-Supplies"; "The Disposal of Refuse Matter of Cities"; "The Disposal of Refuse Matter of Villages, Summer Resorts, and Isolated Tenements"; and "Animal Diseases dangerous to Man."

THE Indian Government has arranged a scheme for the complete and systematic botanical survey of India, for which purpose the country has been divided into four great districts, with a superintendent of survey in each. The flora of the Philippine Islands has been under study by Dr. Sebastian Vidal, Director of the Botanical Garden at Manila and the commission for studying the forest flora; and the work is provided for, for still another year at least, in the public budget.

SIR LYON PLAYFAIR, in opening a new Industrial Institute at Bromley, England, recently, said that hitherto the country had prided itself upon the practical knowledge of its artisans, but it had relied too entirely upon that knowledge. The consequence had been that the countries which nurtured the intellects of the people had stepped in, and with their superior mental education had showed the world that the competition of the day was not one of local advantages, but a competition of intellect. England was realizing her position now, and training her sons by technical schools to compete intellectually with the countries round her, from whom she had learned her lesson.

MR. GEORGE H. BLAGROVE, in a paper on "House Construction in Relation to Health," suggests that great sanitary advantages might be gained if towns were laid out with the streets in the diagonal directions—northeast and southwest, northwest and southeast. Some of the suburban towns near New York are laid out in this way, and—the sun shining into all the rooms some time during every day in the year, and nearly every day into all the windows—the effect is very cheering and salutary.

THE fact is suggestive of the intensity of the strain of city life, that, while from 1852 to 1868 the population of Chicago increased 5·1 times and the death-rate 3·7 times, the deaths from nervous disorders increased 20·4 times.

RATS are accustomed to inhabit the buildings at South Kensington while the exhibitions are in progress. When the exhibitions close, they become starved, and leave the buildings in obviously great numbers. The rat population appears to have been greater than ever during the recent Colonial and Indian Exhibition, and they appeared everywhere, even eagerly going into the traps, which they avoided at other times. At length they entered upon a struggle for existence among themselves, and kept it up till all the young and weaker rats were devoured.

Among the relics found in the high mound, on the Ohio River, opposite Portsmouth, Ohio, were two crosses and thirty buckles of silver. The crosses were decorated with leaves, but furnished no clew as to their date; but one of the buckles, which was heart-shaped, bore the French crown of 1730 or 1740. The whole outfit probably belonged to a convent of one of the Jesuit missionaries. The discovery indicates that the mound was used for burials down to quite recent times.

Emin Bey, as he is known, Emin Pasha, as he has been promoted to be, Dr. Schnitzler, as he is in his patronymic, has been for ten years in the Egyptian service, for most of the time successful governor of the Equatorial Province. He has done much for science through his contributions to Petermann's "Mitteilungen" and the "Proceedings" of the Zoölogical Society; and he is described in "Nature" as "a good type of the kind of explorer that is wanted, now that mere pioneering work has been pretty well exhausted; a man well qualified by his scientific training to remain in a particular region for years if necessary, and study it in all its aspects."

Dr. Frantzel, of Berlin, reporting on the effects of immoderate smoking upon the heart, says that smoking, as a rule, agrees with persons for many years, although by degrees cigars of a finer flavor are chosen. But all at once, without any assignable cause, troubles are experienced with the heart, which compel the calling in of the doctor. Common cigars are not so liable to produce these effects as the finer flavored ones. Nor can the charge be laid upon cigarettes, although they produce evils of their own. The troubles seldom begin till after the smoker is over thirty years of age, and most usually attack him at between fifty and sixty. While it has not been determined what it is that makes smoking injurious, it appears certain that the effect does not depend upon the amount of nicotine.

Mr. W. Doberck, Director of the Hong-Kong Observatory, has prepared a table of the relative frequency per year of dangerous storms in different seas and gulfs, which shows the following results: Arabian Sea, 70; Bay of Bengal, 115; Southern Indian Ocean, 53; Java Sea, 12; China Sea, 214; Gulf of Mexico, 355. The hurricanes of the Antilles and the typhoons of the China Sea show a kind of monthly variation. The former have their maximum in August and their minimum in January; with the latter, the maximum is in December and the minimum in February. In the Java Sea and the Southern Indian Ocean, the maximum occurs in February; in the Bay of Bengal, in October; and in the Arabian Sea, in June.

Two of the recent grants made by the trustees of the Elizabeth Thompson Science Fund are in aid of American work: one of two hundred dollars for the investigation of underground temperatures by a committee of the Natural History Society; and one of five hundred dollars to Professor E. D. Cope, to secure the services of a skilled *preparateur* in working out the material accumulated for the continuance of his researches on American fossil vertebrates.

OBITUARY NOTES.

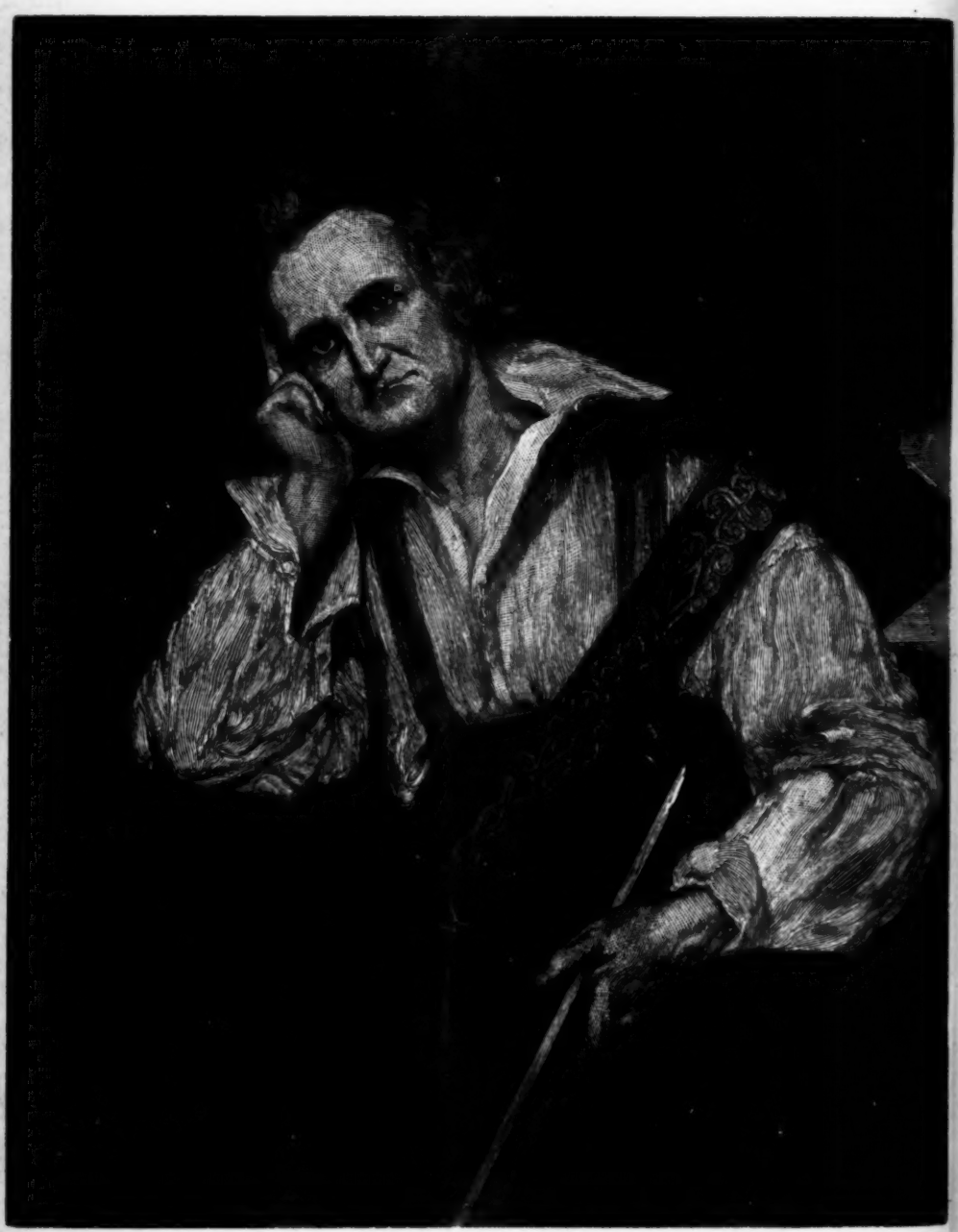
Thomas Stevenson, the eminent constructor of the Bell Rock and numerous other lighthouses, died May 8th, in the sixty-ninth year of his age. He bore a part in the designing and construction of thirty lighthouses, and in numerous river, harbor, and dock works. The results of his experiments on the force, height, and action of sea-waves, are published in his book "On the Design and Construction of Harbors." He was the author of great improvements in lighthouse-lighting, and the optical apparatus in each of his lighthouses was especially adapted to the situation. The results of his researches on this point are given in the book "Lighthouse Construction and Illumination," which has been translated into German. He was also interested in theological questions, and wrote tracts upon them.

Professor Johan Edvard Areschoug, the Swedish botanist, died in Stockholm, May 7th, in the seventy-seventh year of his age. He was made Reader in Botany in the University of Lund in 1839, and was appointed Professor of Botany in the University of Upsala in 1858. He held the last position till 1876. He was the author of numerous papers and monographs on botanical subjects.

Dr. Albert Kellogg, botanist, died in Alameda, California, March 31st, at seventy-four years of age. He was born in Connecticut, and went to California in the early days of its American settlement. He investigated the botany of California during more than thirty years; was one of the founders of the California Academy of Sciences, to whose "Proceedings" he was a frequent contributor; and was attached to the special expedition to Alaska in 1867 as surgeon and botanist.

The death is reported of Dr. Alexander Ecker, professor at the University of Freiburg, in the seventy-first year of his age. He was a distinguished anatomist and pathologist, and was founder of the Ethnographical Museum at Freiburg.

Dr. Karl Friedlander, professor at the University of Berlin, an eminent pathologist and anatomist, has recently died.



J. J. AUDUBON.